Tugboat Compliance with the International Maritime Organization Area to be Avoided off the Washington Coast

Final Report to the Washington State Oil Spill Advisory Council

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LIST OF ABBREVIATIONS

ABS	American Bureau of Shipping
AIS	Automatic Identification System
ATBA	Area to be Avoided
CFR	Code of Federal Regulations
CVTS	Cooperative Vessel Traffic Service
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRT	Gross Registered Tonnage
IMO	International Maritime Organization
kts	Knots (nautical miles per hour)
MAREX	Marine Exchange of Puget Sound
MCTS	Canadian Coast Guard Marine Communications and Traffic Services
MISLE	Marine Information for Safety and Law Enforcement Database
MSIS	Marine Safety Information System Database
NDBC	National Data Buoy Center
nm	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
OCNMS	Olympic Coast National Marine Sanctuary
RCW	Revised Code of Washington
TSS	Traffic Separation Scheme
USCG	United States Coast Guard
VEAT	*Vessel Entries and Transits for Washington Waters*
VHF	Very High Frequency
VTS	Vessel Traffic Service

EXECUTIVE SUMMARY

Washington's pristine northern outer coast is rich in environmental, natural, and cultural resources. Due in part to the presence of these resources, the outer coast is also an economically important region of the state. The unique attributes of the northern outer coast have garnered national recognition, and in 1994 nearly 2,500 square nautical miles of waters off the coast were designated the Olympic Coast National Marine Sanctuary (OCNMS).

The outer coast and National Marine Sanctuary are especially vulnerable to the environmental, economic, and social consequences of a spill of oil or hazardous materials. Drift and powered vessel groundings contribute to the threat of a spill facing the north coast, but the risk of these accidents occurring can be reduced by routing vessel traffic away from shore. In 1995, International Maritime Organization (IMO) implemented offshore vessel traffic routing as a tool to help mitigate the risk of pollution associated with marine commerce around the Sanctuary by establishing the Area to be Avoided off the Washington Coast (ATBA). The ATBA extends approximately 25 nautical miles off the Washington coast from Copalis Head in the south to the Strait of Juan de Fuca in the north. IMO requests that all ships 1,600 gross tons and above solely in transit and all ships and barges carrying cargoes of oil or hazardous materials remain outside of the Area.

Although the ATBA is a voluntary traffic routing measure, OCNMS monitors vessel traffic through the Area and calculates estimates of vessel compliance with its provisions. While the OCNMS compliance estimates indicate that most vessels are complying with the ATBA, the estimated compliance rates for tugs towing oil barges and tugs towing chemical barges are consistently lower than compliance estimates for other vessel types. However, the validity of the tug compliance rates have been challenged due to certain facets of OCNMS' vessel traffic dataset and the manner in which the estimates are calculated. This report attempts to examine some of the issues that have led to criticism of the tugboat compliance estimates, and to investigate several factors that could be associated with or related to any observed lack of tug compliance.

One critique of the Sanctuary's tugboat compliance estimates is that they count empty barge transits through the ATBA as noncompliant. These estimates could under represent compliance, as the provisions of the Area do not apply to barges unless they are carrying cargoes of oil or hazardous materials. During the 2005 calendar year, classifying empty barge transits through the ATBA as compliant results in an estimated compliance rate for tugs towing oil barges of 90.9% (versus an 82.5% compliance rate if both laden and empty barges passing through the ATBA are treated as though they are noncompliant) and an estimated compliance rate for tugs towing chemical barges of 57.1% (versus a 35.7% compliance rate if both laden and empty chemical barges passing through the ATBA are treated as though they are noncompliant).

Analysis of vessel traffic data from 2005 indicates that many of the laden oil barge transits through the ATBA involved relatively shallow incursions into the Area. Twenty five of the 52 noncompliant laden oil barge transits passed less than 0.25 nautical miles into the ATBA. Forty of the 52 noncompliant oil barge transits passed less than one nautical mile into the Area. Laden noncompliant chemical barges generally went deeper into the ATBA than laden noncompliant oil barges. During 2005, all six noncompliant tugs towing laden chemical barges passed more than 1.25 nautical miles into the Area.

Noncompliant and compliant tugs' next and last ports of call were reviewed to determine if a disproportionate amount of noncompliant tugs called at a certain port or port area, and to see if there was any association between a tug's direction of travel (into the Strait of Juan de Fuca or outbound from the Strait of Juan de Fuca) and barge status (empty or laden) in 2005. A large percentage of both noncompliant *and* compliant tug transits ended at ports on the Lower Columbia River. Additionally, for the 2005 calendar year, there is convincing evidence of an association between tugs' direction of travel (inbound/outbound) and barge status (empty/laden). Approximately 83% of inbound petroleum barges were empty and approximately 95% of outbound petroleum barges were laden.

IMO recommends that slower moving vessels – including tugs – use the Two-Way Route in the Strait of Juan de Fuca south of the primary traffic separation scheme (TSS) to reduce the occurrence of overtaking situations in the TSS. As the Two-Way Route keeps tugs closer to the Washington coast and the ATBA than these vessels would be if they used the lanes in the TSS, tug tracklines were investigated in an attempt to isolate a possible association between tug use of the Two-Way Route and passage through the ATBA. While the majority of noncompliant tugs did use the Two-Way Route during 2005, there is only marginal evidence of an association between Route usage and incursions into the ATBA.

Offshore weather conditions could influence a tug crew's decision to make a noncompliant transit through the ATBA. Data on offshore weather during all noncompliant transits and a random sample of transits that did not pass through the ATBA failed to reveal evidence of an association between weather conditions and compliance for 2005. Most transits (both noncompliant transits and the sample of transits outside the ATBA) took place when sustained winds were less than 21 knots and significant wave heights were less than ten feet.

A review of historical incident and accident data showed that there were at least 14 events involving tugs towing oil or hazardous materials barges along Washington's outer coast between 1994 and the end of 2006. There could have been as many as 15 additional incidents and accidents involving tugs towing oil or hazardous materials barges off the coast during this same time period, but data on these 15 additional events was too scanty to permit confirmation of the vessels' cargoes or locations.

Several recommendations for future research bear consideration. First, it is suggested that additional studies of issues related to ATBA compliance would benefit from Automatic Identification System data on vessel traffic. Second, the possible association between vessels' use of the Two-Way Route and passage through the ATBA could be more rigorously analyzed. Third, improvement of existing incident and accident datasets would help facilitate studies reliant on information about historical incidents and accidents. Finally, the risks posed by fish processors engaged in operations in the OCNMS might warrant further investigation.

CHAPTER 1: BACKGROUND AND INTRODUCTION

1.1 *Washington's Northern Outer Coast and the Olympic Coast National Marine Sanctuary*

Washington's northern outer coast is known for its rich environmental, cultural, and natural resources. Considered by many to be "pristine" (1-5), the northern outer coast is the most undisturbed major section of coastline in the contiguous United States (4, 6).

The region's diverse habitats and productive waters support a variety of marine mammals, birds, fish, and invertebrates. Sea lions, porpoises, seals, and Washington's only population of sea otters rest and breed along the coast (4, 7). Whales transit through and feed in coastal waters (8). The outer coast's seabird colonies are some of the largest in the continental United States (4). Salmon, trout, and various groundfish take advantage of kelp beds, reefs, and other attributes of the coastal environment (4, 8). Invertebrates including abalone, scallops, sea urchins, crabs, shrimp, and clams also thrive in the area (4, 8). Several of the species living on the outer coast are listed as Threatened or Endangered under the Federal Endangered Species Act (5).

The Hoh, Makah, Quileute, and Quinault tribes all have reservations along the coast, and many local resources are of great significance to the tribes for both cultural and spiritual purposes (2, 4, 9). There are also numerous archaeologically significant sites in the region (4).

Some of these qualities of the outer coast contribute to the area's economic importance. The North Puget Sound Long Term Oil Spill Risk Management Panel asserts that the northern outer coast "contains the most valuable marine natural resources in Washington State" (1). Several species of fish and shellfish that use or reside in the waters along the outer coast are harvested both recreationally and commercially. During 2006, revenue from commercial fish catches exceeded $11.3 million in Clallam County and $4.6 million in Jefferson County (10). Tourism is also important in the area. During 2005, wages from the leisure and hospitality sector exceeded $46.6 million in Clallam County and $17.2 million in Jefferson County (11)[1].

While parts of the Washington mainland along the north coast and many of the small islands off the coast are protected in the Olympic National Park and the Flattery Rocks, Quillayute Needles, and Copalis National Wildlife Refuges (12), the region's marine resources are protected in the Olympic Coast National Marine Sanctuary. The National Marine Sanctuaries Act (16USC1431-45) permits the Secretary of Commerce to designate areas of special national significance as national marine sanctuaries to ensure comprehensive management and conservation of these areas. In 1988 Congress acknowledged that the Olympic Coast "possesses a unique and nationally significant collection of flora and fauna" (4) and in 1994 almost 2500 square nautical miles of waters off the Washington coast (Figure 1) were designated the Olympic Coast National Marine Sanctuary (15CFR922.150).

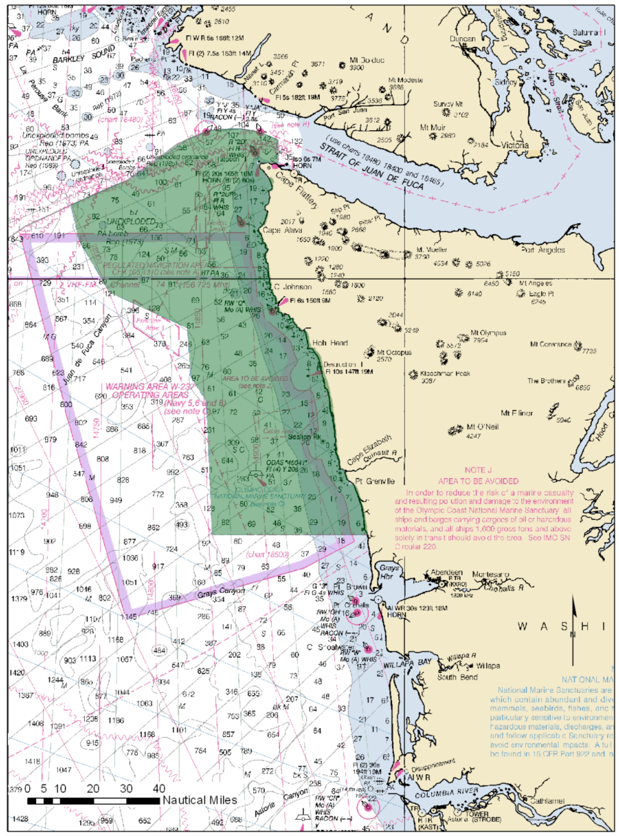

Figure 1: Olympic Coast National Marine Sanctuary (green shaded area)

1.2 *Spills of Oil or Hazardous Materials along Washington's Northern Outer Coast*

The northern outer coast and the Olympic Coast National Marine Sanctuary are especially vulnerable to the environmental, economic, and social consequences of a spill of oil or hazardous materials. In their Final Environmental Impact Statement and Management Plan for the Sanctuary, the Department of Commerce comments on the extreme sensitivity of

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[1] These values reflect catch revenues and wages for all of Jefferson and Clallam Counties.

the Pacific coast environment to oil spills (4). This concern is echoed in reports compiled by Washington Department of Ecology (5, 7) and the United States Department of Transportation (9). The North Puget Sound Long Term Oil Spill Risk Management Panel acknowledges the possible cultural effects of a spill on the outer coast (1). Models run as a part of a United States Coast Guard study also predict spill impacts on local recreation and wilderness areas, including Olympic National Park (3). Olympic Coast National Marine Sanctuary even lists a spill of oil or hazardous materials as one of the “greatest threats” to the Sanctuary (13).

Two of the principal types of accident that could result in a spill of oil or hazardous materials along the northern outer coast are drift and powered groundings. Merrick et al. (14) define a drift grounding as a drifting vessel “out of control because of a propulsion or steering failure making contact with the shore or bottom,” and a powered grounding as an underway vessel “under power making contact with the shore or bottom because of navigational error or steering failure and lack of vigilance.” In the 1997 Volpe National Transportation Systems Center scoping risk assessment, *Protection Against Oil Spills in the Marine Waters of Northwest Washington State*, researchers found that the “accident types most likely to cause a spill are collisions and both powered and drift groundings” (9). Although this statement applies to all marine waters from Olympia to the Canadian border, through the San Juan Islands, and out into the approaches to the Strait of Juan de Fuca, the United States Coast Guard supports this finding with regard to the outer coast. One Coast Guard report interprets the distribution of risk[2] outlined in the Volpe risk assessment as it applies to the Strait of Juan de Fuca and its offshore approaches. The report’s authors assert that collisions, drift groundings, and powered groundings pose the greatest risks in this region (16). Another Coast Guard report states that, in the waters of the Olympic Coast National Marine Sanctuary and the Strait of Juan de Fuca, “the principal threat to the environment posed by a disabled vessel is that of an oil spill resulting from the vessel drifting aground” (2).

[2] Risk is defined as the “product of the probability of an event occurring and the consequences of that event occurring;” *Risk = Probability × Consequences* (15).

One way to reduce the risk of a spill from a drift or powered grounding is to route vessel traffic away from the coast. In 2002, the West Coast Offshore Vessel Traffic Risk Management Project Workgroup found that the risk of vessel groundings usually decreases the farther vessels transit from shore (17). Galasso also asserts that routing vessels offshore can address risks associated with drift and powered groundings (18). The North Puget Sound Long Term Oil Spill Risk Management Panel and United States Coast Guard agree with the Offshore Workgroup and Galasso in this regard (1, 19). There are several reasons why offshore routing can be effective at mitigating spill risks. If a vessel loses power or maneuverability, the farther that vessel is from shore, the more time there is for repairs to be affected or for help to arrive before the vessel drifts aground. This extra time can also provide onshore responders with an opportunity to prepare for the possibility that the disabled vessel will ground (4). Finally, operators on vessels transiting farther from shore have a greater margin for navigational errors that could result in a powered grounding than operators on vessels transiting close to shore.

In 1995, International Maritime Organization implemented offshore vessel traffic routing as a tool to reduce the risk of drift and powered groundings in the OCNMS by establishing the Area to be Avoided off the Washington Coast (ATBA) (20).

1.3 *The Area to be Avoided off the Washington Coast and Estimates of Vessel Compliance*

IMO defines an Area to be Avoided as an area "in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships, or by certain classes of ships" (21). IMO's Maritime Safety Committee adopted the Area to be Avoided off the Washington Coast in December of 1994, proclaiming, "In order to reduce the risk of a marine casualty and resulting pollution and damage to the environment of the Olympic Coast National Marine Sanctuary, all ships, including barges, carrying cargoes of oil or hazardous materials should avoid the area[3]" (22). The provisions of the original ATBA became effective 7 June 1995.

Following the completion of the Coast Guard's *Port Access Route Study for the Strait of*

[3] This statement does not apply to government vessels.

Juan de Fuca and Adjacent Waters, IMO moved the northern corner of the original ATBA over one and a quarter nautical miles to the north and almost nine nautical miles to the west. The new ATBA, which extends approximately 25 nautical miles off the Washington coast from Copalis Head in the south to the Strait of Juan de Fuca in the north (Figure 2), went into effect 1 December 2002. In addition to expanding the geographic coverage of the ATBA, IMO also changed the types of vessel to which the Area applies. The new ATBA still applies to "all ships and barges carrying cargoes of oil or hazardous materials," but also to "all ships 1,600 gross tons and above solely in transit" (23). Government vessels, including warships, naval auxiliary vessels, barges (whether towed by a government or commercial tug), or other government owned or operated ships being used only on government non-commercial service remain exempt from the provisions of the ATBA (23).

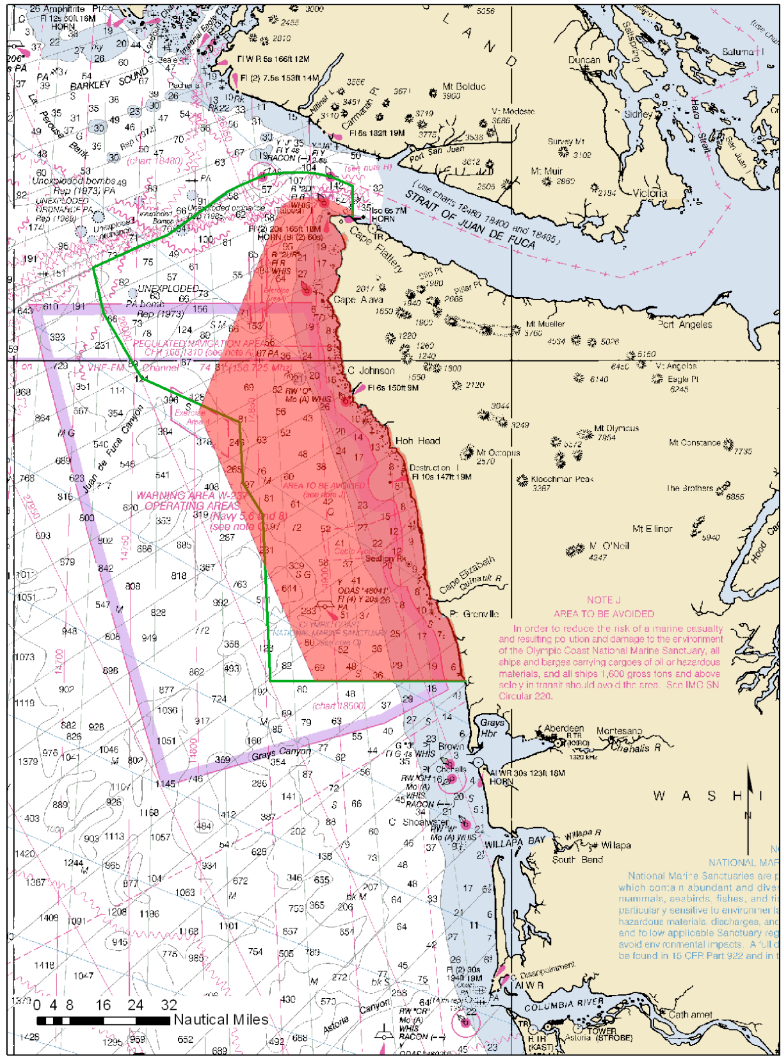

Figure 2: The Area to be Avoided off the Washington coast (red shaded area; outline of OCNMS shown in green)

The United States Coast Guard interprets "hazardous materials," as they apply to the ATBA, to include cargoes listed in 40CFR302.4 – Designation of Hazardous Substances (Table 302.4, List of Hazardous Substances and Reportable Quantities), 40CFR116.4 – Designation of Hazardous Substances (Table 116.4A, List of Hazardous Substances), 40CFR117.3 – Determination of Reportable Quantities (Table 117.3, Reportable Quantities of Hazardous Substances Designated Pursuant to Section 311 of the Clean Water Act), and 49CFR172.101 – Purpose and Use of Hazardous Materials Table (Hazardous Materials Table). "Oil" is defined in 40CFR112.2. A variety of substances classified as oil (for example, animal fat, non-petroleum oil, petroleum oil, and vegetable oil) are also defined in 40CFR112.2. The Coast Guard maintains a list of specific petroleum and non-petroleum oils on their *Vessel Response Plans and Shipboard Oil Pollution Emergency Plans* website (24).

Information about the ATBA is available to mariners on navigational charts and the OCNMS website, and is published in *United States Coast Pilot 7*, *Vessel Entries and Transits for Washington Waters*, and *Vessel Traffic Service Puget Sound User Manual*. OCNMS also contacts certain vessels that transit the ATBA with information on the Area's provisions as a part of their ATBA Education and Monitoring Program (18).

It is important to recognize that the ATBA is a voluntary traffic routing measure. IMO states that certain vessels *should* avoid the Area, not that they *must* avoid the Area. Although compliance with the ATBA is voluntary, OCNMS has developed performance indicators based on vessel traffic data to assess ATBA compliance rates. The Sanctuary stresses that their annual compliance rates, published in Washington Department of Ecology's *Vessel Entries and Transits for Washington Waters* (VEAT), do not represent absolute ATBA compliance, but are meant to "track the relative effectiveness of the ATBA initiative" (18, 25).

OCNMS calculates compliance rates after analyzing vessel traffic data to isolate the number and type of vessels transiting the Sanctuary and the ATBA. In the VEAT, the estimated ATBA compliance rate is defined as the percentage of vessels that pass through the Sanctuary that do not pass through the ATBA:

$$Estimated\ \ ATBA\ \ Compliance\ \ Rate = \left(1 - \frac{Transits\ \ Through\ \ ATBA\ \ Within\ \ Sanctuary}{Transits\ \ Through\ \ Sanctuary}\right) \times 100\%$$

Vessel transits through the Sanctuary are used in these calculations (instead of considering all vessel transits through the Strait of Juan de Fuca) to correct for north and west bound vessels that would have no reason to pass through the ATBA to begin with (18).

Estimated ATBA compliance rates are calculated by vessel type, as classified by Washington Department of Ecology in the VEAT, and are relatively high. Several types of vessel have annual compliance rates exceeding 98%, with some types of vessel being 100% compliant. However, tugs towing oil barges and tugs towing chemical barges generally seem to have lower compliance rates than other types of vessel included in the VEAT. In 2004, OCNMS estimated that tugs towing oil barges had a 75.2% ATBA compliance rate and tugs towing chemical barges had a 43.8% ATBA compliance rate compared to an overall compliance rate (for all vessels including tugs towing chemical and oil barges) of 96.3% (26). In 2005, OCNMS estimated that tugs towing oil barges had an 82.5% ATBA compliance rate and tugs towing chemical barges a 35.7% ATBA compliance rate compared to an overall compliance rate of 97.3% (27). Finally, in 2006, OCNMS estimated that tugs towing oil barges had a 78.2% ATBA compliance rate and tugs towing chemical barges a 57.1% ATBA compliance rate compared to an overall compliance rate of 97.3%[4] (28).

See Appendix A for the 2004, 2005, and 2006 VEAT ATBA compliance estimates.

[4] 2006 VEAT compliance estimates are based on vessel traffic data from only part of the 2006 calendar year (28).

CHAPTER 2: PROJECT OVERVIEW AND DATA USED

2.1 *Project Overview*

The validity of the ATBA compliance rates for tugs and barges outlined in the VEAT has been contested (29, 30), and the Sanctuary advises readers of the VEAT that the VEAT compliance rates are estimates that are “not known with certainty” (27). This report attempts to examine some of the issues that have led to criticism of the VEAT compliance estimates, and to investigate several factors that could be associated with or related to any observed lack of tug compliance. Specifically, the report focuses on:

- Vessel compliance rates accounting for empty barges,
- The magnitude of noncompliant tug incursions into the ATBA,
- A possible association between tug compliance and tugs’ ports of call,
- A possible association between tug transits through the ATBA and tug traffic patterns in the Strait of Juan de Fuca,
- A possible association between tug compliance and offshore weather conditions,
- The assumption that tug transits into the Strait of Juan de Fuca are predominantly made in ballast[5], and
- Relevant incidents and accidents involving tugs and barges off the Washington coast

2.2 *Vessel Traffic Data*

The data on vessel traffic required for these analyses is collected by Vessel Traffic Centers participating in the joint Canadian and United States Coast Guard’s Cooperative Vessel Traffic Service (CVTS). In 1979, the CVTS was established to facilitate management of vessel traffic passing through United States and Canadian waters in and around the Strait of Juan de Fuca (31). The area covered by the CVTS is broken into three zones: Seattle, Victoria, and Tofino. Vessels transiting these zones are handled by Seattle Traffic, Victoria Traffic, and Tofino Traffic.

[5] For the purposes of this report, transits made “in ballast” are defined as those involving tugs towing barges that are not carrying cargo.

Tofino Vessel Traffic Service's (VTS) area of responsibility covers the waters between 124°40'W in the east, 127°00'W in the west, and 48°00'N in the south, as well as waters within 50 nautical miles (nm) of the west coast of Vancouver Island (31). This region includes the northern 26nm of the ATBA. All ships twenty meters (approximately 66 feet) or more in length, and all ships engaged in towing or pushing any vessel or object (where the length of the vessel or object being towed or pushed by the ship is twenty meters or more in length) must participate in the CVTS when in the Tofino VTS zone (32).

Tofino VTS monitors these vessels' positions using an S-Band radar transceiver[6] located on Mt. Ozzard, Vancouver Island. The Mt. Ozzard transceiver has a range of 60nm, which covers the northern section of the ATBA (Figure 3) (33). In addition to logging vessels' positions as determined by the Mt. Ozzard transceiver, Tofino VTS records a variety of data about vessels participating in the CVTS, such as their type, length, flag state, gross registered tonnage (GRT), next and last port of call, and the status of any barges (empty or laden) that a vessel has in tow.

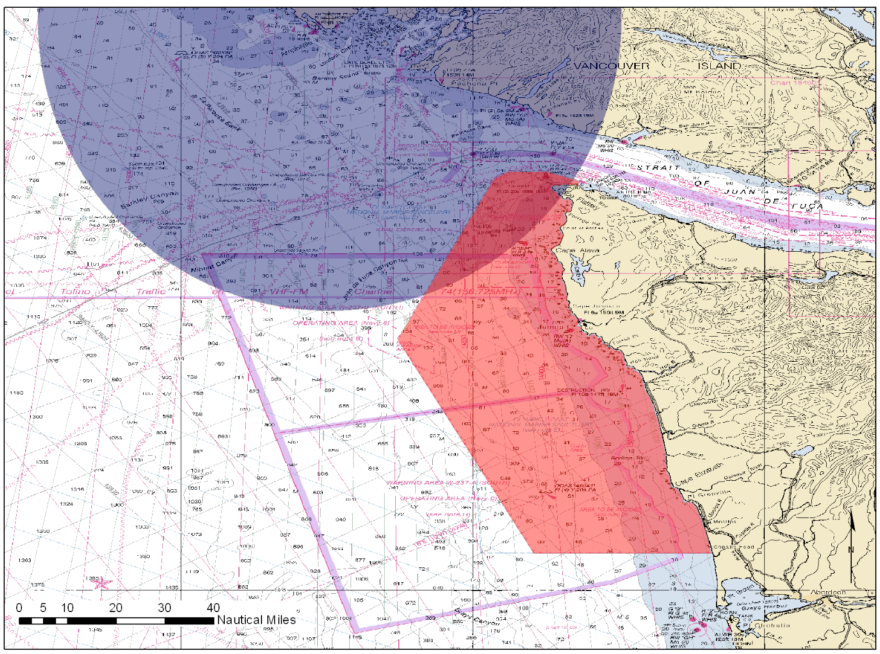

Figure 3: Coverage of the Mt. Ozzard radar transceiver (blue shaded area; ATBA shaded red)

OCNMS gathers this data from Tofino VTS, processes it, and inputs it into a Geographic Information System (GIS) (34). The Sanctuary can then analyze vessel tracklines with its GIS to determine which vessel transits pass through the ATBA or the Sanctuary.

[6] The S-Band transceiver was replaced with an X-Band transceiver in September 2006. However, during the period for which data used in this study was collected, the S-Band transceiver was still in service (33).

Information on vessel transits through the ATBA and Sanctuary is used to compile the VEAT compliance estimates outlined above[7].

A subset of OCNMS' processed vessel traffic data served as the foundation for this study. The following data on vessels included in the 2005 VEAT statistics (2005 calendar year) was available for analysis:

- Vessel trackline
- Vessel class (for example, Tug/Barge, Tank Vessel, Freighter)
- Date and time of the first radar fix, and the vessel's course and speed at this time
- The vessel's first recorded position (latitude and longitude)
- Trip ID, a unique identifier for each vessel transit
- Vessel ID, a unique identifier for each vessel
- The vessel's flag state (where the vessel is registered)
- Vessel type, length overall, and gross registered tonnage
- For tugs with barges, the type of barge being towed (oil or chemical) and that barge's status
- The vessel's last and next port of call
- Whether a particular vessel transit involved a vessel passing through the ATBA or the Sanctuary

2.3 *Weather Data*

Archived data from National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) stations along the outer coast was used to determine weather conditions for the study. Two stations, 46087 and 46041, were the sources of this weather data (35). Station 46087 is a three-meter discus buoy[8] (Buoy *JA*) located at the entrance to the Strait of Juan de Fuca. Station 46041 (Cape Elizabeth) is a three-meter discus buoy

[7] Annual VEAT reports do not include information on all vessel traffic monitored by Tofino VTS (34). For example, statistics on government and research vessels are not outlined in the VEAT lists of estimated ATBA compliance rates.

[8] NDBC maintains a fleet of weather buoys of different shapes and sizes. The type of buoy deployed in a specific location depends on the prevailing conditions at that location and the instrumentation to be placed on the buoy. Three meter discus buoys are aluminum buoys, three meters in diameter, with circular hulls (36).

located 45nm northwest of Aberdeen (Figure 4). Both buoys collect data on wind speed and wave height.

2.4 *Incident and Accident Data*

As there is no single comprehensive repository of vessel incident and accident data[9] (39), several sources were reviewed for information on incidents and accidents involving tugs towing oil or hazardous materials barges off the Washington coast.

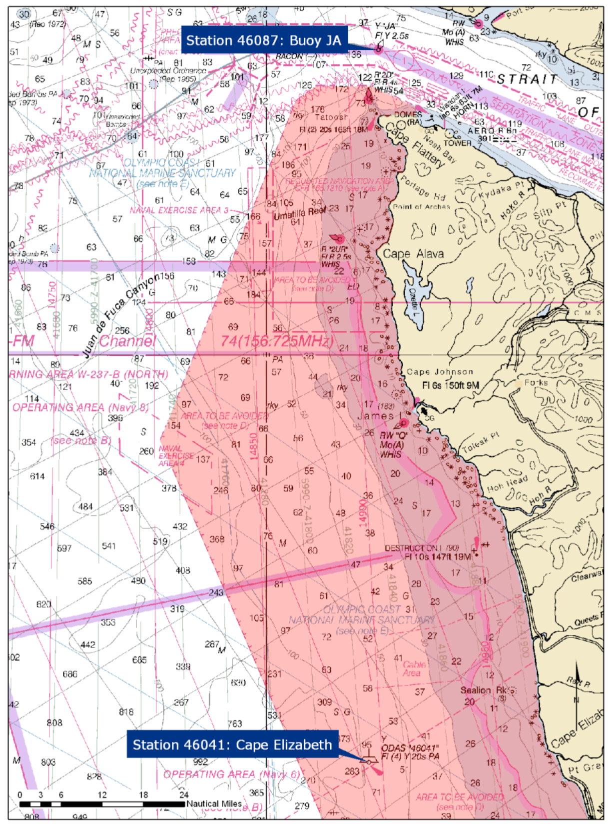

Figure 4: NDBC Station 46087 and Station 46041

In December of 2001, the United States Coast Guard began to archive records of casualty investigations reportable under 46CFR4.03 and pollution investigations reportable under 33CFR153.203 in their Marine Information for Safety and Law Enforcement (MISLE) database (40). Information on casualty investigations that took place from 1992 to December 2001, originally stored in the Marine Safety Information System (MSIS) database, has been migrated to MISLE (40). The Coast Guard provided data from MISLE on reportable incidents and accidents involving tugs and barges off the Washington coast between the entrance to the Strait of Juan de Fuca and the entrance to the Columbia River for this study.

[9] Harrald et al. define an accident as an “event such as a collision or grounding that has adverse consequences (e.g., injury, loss of life, economic loss, environmental damage)” (37). Incidents are defined in the Marine Operations Risk Guide as conditions that may lead to an accident (38). For example, a loss of propulsion (an event that might result in a grounding) could be classified as an incident.

Since 1995, Washington Department of Ecology has kept records of collisions, groundings, losses of propulsion or steering, casualties, and oil spills involving commercial vessels 300 gross tons and above (5). These records are based on reports from vessels involved in the events[10] and on additional data from the United States Coast Guard (5). Department of Ecology data on incidents and accidents in North Puget Sound (including the approaches to the Strait of Juan de Fuca) and the Columbia River (including the approaches to the Columbia River) was made available for this study.

A variety of additional reports, press releases, and other documents also provided information on incidents and accidents off Washington's outer coast. OCNMS and the Sanctuary report, *Olympic Coast National Marine Sanctuary Area to be Avoided Education and Monitoring Program*, discuss several tug and barge incidents and accidents occurring between 1994 and 1999 (18, 41). The Department of Ecology report, *Neah Bay Rescue Tug: Report to the Washington State Legislature*, and web pages, *Neah Bay Rescue Tug Summaries of Responses Since 1999*, *Rescue Tug Called Out to Stand By to Assist in Drifting Barge Recovery*, and *Tank Barge* Nancy Jo *Broken Tow Wire Incident* review relevant tug and barge accidents and incidents (5, 42-44). The West Coast Offshore Vessel Traffic Risk Management Project final report lists incidents and accidents that occurred between 1992 and 1999 along the west coast (17). Finally, Joint Information Center press releases address the 2005 *Howard Olsen / Millicoma* accident (45-50).

2.5 *Data Limitations: Vessel Traffic Data*

As depicted in Figure 3 above, the 60nm range of the Mt. Ozzard radar transceiver does not cover the entire ATBA. Any traffic that passes through the ATBA south of Cape Johnson (and some traffic near the coast north of Cape Johnson) will be missed by the Mt. Ozzard transceiver. This restricted zone of radar coverage is one reason why it is inappropriate to treat ATBA compliance estimates calculated from Tofino VTS radar data as absolute compliance rates.

[10] Vessel reporting requirements for accidents and near miss incidents are outlined in RCW88.46.100, "Notification of accidents and near miss incidents."

The 0.6nm positional accuracy of Tofino VTS radar fixes is not ideal for this kind of study, as it introduces uncertainty into the classification of vessels traveling near the boundary of the ATBA. The accuracy of OCNMS' vessel tracklines is also impacted by the temporal distribution of the Sanctuary's data points on vessel position. Tofino VTS provides OCNMS with data on vessel positions that has been archived at six-minute intervals (51). Vessel tracklines are then created by assuming straight-line tracks between these fixes (34). The assumption that a vessel transits in a straight line between fixes is not always valid, and there is some error associated with data reliant on this straight-line interpolation method[11].

OCNMS outlines a series of issues related to data processing that highlight imperfections in their vessel traffic dataset (34). Double transits (two transits treated as a single transit), an inability to capture alterations in the characteristics of a vessel involved in a particular transit following initial logging of vessel attributes, continued logging of a vessel's last position after loss of radar contact, and manual manipulation of vessel tracklines by VTS Operators are all examples of these imperfections. The Sanctuary also discusses how questionable positional fixes, arising due to the nature of the Tofino VTS system, are filtered from their final dataset (34). While this filtering is necessary, it is possible that valid data points might be inadvertently discarded as a part of the filtering process.

Outside of these facets of the vessel trackline data, some of the certainty surrounding the attributes associated with each vessel trackline must be qualified. One attribute of concern for this study is barge type and status. Operators onboard tugs towing barges report the type of barge (oil barge, bulk barge, chemical barge, etc.) and the barge's status (laden or empty) to the appropriate VTS upon entry into the CVTS (51). However, tug crews are not provided with a concrete metric for classifying barges as empty or laden. As reports on barge status provided to VTS Operators are based on subjective judgments of individual tug crews, the definition of laden or empty could vary amongst vessel transits included in the Tofino VTS dataset.

While vessel traffic data from Tofino VTS is not perfect, it is also not invalid. The United States Coast Guard endorsed information gathered from local Vessel Traffic Centers with

[11] A tug traveling at 8kts will cover 0.8nm in six minutes.

the statement, "VTS is considered a reliable source for transit data," and used Tofino and Seattle VTS radar data to determine the distribution of commercial vessels around the Strait of Juan de Fuca in their regulatory assessment of tugs as tools for spill prevention (3). In 2006, OCNMS also commented on the value of Tofino VTS data, "data from the Tofino Vessel Traffic Center… is currently the best source of data for the area" (34).

2.6 *Data Limitations: Weather Data*

NOAA NDBC weather stations might not provide a completely accurate representation of weather conditions off the Washington coast. Nuka Research recently highlighted possible errors in wind speed and wave height measurements from NDBC buoys like Station 46087 (Buoy *JA*) and Station 46041 (Cape Elizabeth) (52). Specifically, winds might be underreported when wind speeds and sea heights are high, and seas might be underreported when there are significant swells and wind waves with different periods. In addition, Galasso notes that anomalous winds and seas (when compared to offshore conditions) have been observed at Buoy *JA* (25). As such, there are times when inferences about offshore weather based on data from Buoy *JA* could be erroneous. Despite these shortcomings, NOAA NDBC stations serve as the most reputable and consistent source of archived data on marine weather along the Washington coast available for this study.

2.7 *Data Limitations: Incident and Accident Data*

Some incidents and accidents involving tugs towing oil and hazardous materials barges off the Washington coast might not be captured in the inventories of these events outlined above. The data and reports from Department of Ecology used in this study focus predominantly on the approaches to the Strait of Juan de Fuca and the Columbia River. It is possible that events occurring in the southern portion of the ATBA and along the southern coast could be absent from Department of Ecology's datasets and event summaries.

The MISLE data from the United States Coast Guard only includes information on completed investigations of events reportable under 46CFR4.03 and 33CFR153.203.

Events that failed to meet these reporting criteria and were not investigated by the Coast Guard (or events for which the investigation remains open) would not be included in the Coast Guard data provided for this study (40). It is also important to note that foreign flag vessels are not required to report casualties[12] to the United States Coast Guard if these casualties occur outside of the United States' territorial sea (the territorial sea extends twelve nautical miles off the coast)[13] (17, 53).

Near misses, defined as "any situation where an incident or accident was narrowly avoided,"[14] are not explicitly catalogued in this report (54). There can be hundreds of near misses for every reportable accident (55). The importance of considering these near misses while attempting to understand the causes and reduce the occurrence of accidents has been recognized by the oil extraction and transportation industry for some time, and is formally acknowledged in the United States Coast Guard's Risk Based Decision-Making Guidelines (56). Other researchers have reached similar conclusions to the Coast Guard and oil industry. For example, DeCola and Fletcher opine that "important safety and prevention information" can be derived from near misses (57). Despite the value of information on near misses, many of these events are not captured in incident and accident databases like those used for this study.

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[12] Marine casualties or accidents are defined in 46CFR4.03-1 as events caused by or involving vessels including, but not limited to, any fall overboard, injury, or loss of life of any person, any occurrence that results in a grounding, stranding, foundering, flooding, collision, allision, explosion, fire, reduction or loss of a vessel's electrical power, propulsion, or steering capabilities, failures or occurrences (regardless of cause) which impair any aspect of a vessel's operation, components, or cargo, any other circumstance that might affect or impair a vessel's seaworthiness, efficiency, or fitness for service or route, any incident involving significant harm to the environment, any occurrences of injury or loss of life to any person while diving from a vessel and using underwater breathing apparatus, and any incident described in 46CFR4.05–1(a).

[13] United States flag vessels are required to report marine casualties or accidents, regardless of where these casualties or accidents occur (46CFR4.03-1). Most of the tugs towing barges included in the 2005 VEAT dataset are United States flag vessels, and it is unlikely that a large number of incidents and accidents involving oil barges in coastwise trade will escape detection due to limits on foreign vessel reporting requirements. However, a significant percentage of the chemical barges in the 2005 VEAT dataset are Canadian flag vessels. If Canadian tugs consistently tow chemical barges along the Washington coast, some events involving these vessels might be omitted from the Coast Guard's casualty datasets.

[14] This is a different definition than the definition of "near miss incidents" used in RCW88.46.100. "Near miss incidents," or incidents that "require the pilot or master of a covered vessel to take evasive actions or make significant course corrections in order to avoid a collision with another ship or to avoid a grounding as required by the international rules of the road," that occur within twelve miles of shore must be reported to the United States Coast Guard and should be included in this report's list of marine casualties.

Finally, various incident and accident reports that were reviewed did not include important information, or included inconsistent or conflicting information, about specific events. Event location, causal information, barge type and status, and an indication of what exactly occurred was lacking for numerous casualties. In situations where data for a particular accident or incident was available from more than one source, the sources sometimes included disparate accounts of the event. A few reports even contradicted themselves. Some of these characteristics of certain incident and accident datasets were also recognized by the West Coast Offshore Vessel Traffic Risk Management Project Workgroup (17). The existence of obvious inconsistencies or conflicting information in numerous reports from a given source draws the accuracy of other reports from that source – even if these other reports are not blatantly erroneous – into question.

CHAPTER 3: RESULTS

3.1 *Laden Tug Compliance Estimates and the Magnitude of Tug Incursions into the ATBA*

One of the primary critiques of the tugboat compliance estimates included in the VEAT is that they do not distinguish between tugs towing empty chemical or oil barges and tugs towing laden chemical or oil barges. It is generally assumed that the provisions of the ATBA are inapplicable to barges that are empty, as these barges are not officially carrying cargoes of oil or hazardous materials. For the purposes of the VEAT compliance rate calculations, however, all tugs towing oil or chemical barges are classified as though they are laden. These rates could underestimate oil and chemical barge compliance, and correcting for tugs towing empty barges through the ATBA might yield more accurate compliance estimates.

In 2005, 596 transits involving tugs towing oil or chemical barges were recorded in the OCNMS VEAT dataset. One hundred and ten of these transits passed through the ATBA, including 52 loaded oil barges, 49 empty oil barges, six loaded chemical barges, and three empty chemical barges. A modified version of the Sanctuary's compliance formula can be used to calculate compliance while addressing the 52 empty oil and chemical barges:

$$Adjusted\ \ ATBA\ \ Compliance\ \ Estimate = \left(1 - \frac{Laden\ \ Transits\ \ Through\ \ ATBA}{Transits\ \ Through\ \ Sanctuary}\right) \times 100\%$$

The Adjusted ATBA Compliance Estimate is defined here as the percentage of vessels that pass through the Sanctuary that do not make a *laden* transit through the ATBA. In the equation for the Adjusted ATBA Compliance Estimate, "Transits Through Sanctuary" includes both laden barge transits through the Sanctuary (but not the ATBA) and empty barge transits through the ATBA (these transits through the ATBA also transit the Sanctuary). Based on the 2005 vessel traffic data, the adjusted compliance rate for tugs towing oil barges is 90.9%, and the adjusted compliance rate for tugs towing chemical barges is 57.1%. Treating empty barges as compliant, then, raises the compliance estimate for tugs towing oil barges by approximately 8% (up from 82.5% to 90.9%) and raises the compliance estimate for tugs towing chemical barges by approximately 21% (up from 35.7% to 57.1%).

While the estimated compliance rates for tugs towing oil and chemical barges increase when empty barge transits through the ATBA are treated as compliant, the adjusted compliance estimates are still lower than the compliance estimates for all other types of vessel except fishing vessels. In 2005, fishing vessels (fish processors) had an estimated compliance rate of 77.2%, but it is likely that this estimate is not an accurate representation of fish processor compliance (see Section 4.4). Refrigerated ships, with a compliance rate of 93.3%, have the next lowest estimated compliance following tugs towing chemical barges and tugs towing oil barges. However, this relatively low compliance estimate is the result of one refrigerated ship transit through the ATBA (there were only 15 total refrigerated ship transits through the Sanctuary during 2005). All vessel types other than fishing vessels, refrigerated ships, and tugs towing oil or chemical barges had estimated compliance rates greater than 98% for the 2005 calendar year.

The 58 transits through the ATBA involving laden oil (52 transits) and laden chemical (6 transits) barges were analyzed in ArcView GIS to determine the severity of these transits' incursions into the ATBA. Tugs' maximum distance into the ATBA, classed in 0.25nm intervals, is outlined in Tables 1 and 2.

Number of Oil Barges	Distance into ATBA
25	Less than 0.25nm
6	0.25-0.5nm
6	0.5-0.75nm
3	0.75-1.0nm
2	1.0-1.25nm
3	1.5-1.75nm
1	1.75-2.0nm
1	2.0-2.25nm
1	2.25-2.5nm
1	2.75-3.0nm
1	4.0-4.25nm
1	5.25-5.5nm
1	7.0-7.25nm
Total = 52	

Number of Chemical Barges	Distance into ATBA
1	1.25-1.5nm
1	6.0-6.25nm
1	6.5-6.75nm
1	7.0-7.25nm
1	7.75-8.0nm
1	11.25-11.50nm
Total = 6	

Table 1 and Table 2: Severity of laden oil and chemical barge incursions into the ATBA

See Appendix B for more detailed information on each of these 58 noncompliant tug transits through the ATBA, including plots of noncompliant vessel tracklines.

With regard to laden oil barges (Table 1), it is notable that almost half of the noncompliant transits involved an incursion of less than 0.25nm into the ATBA. More than 75% of the transits passed less than a mile into the Area (40 transits). If those tugs that passed less than 0.25nm into the ATBA are treated as compliant, the estimated compliance rate for tugs towing oil barges increases to 95.3%.

Tugs towing chemical barges (Table 2) had different patterns of noncompliance during 2005 than tugs towing oil barges. In general, noncompliant chemical barge transits involved deeper incursions into the ATBA than noncompliant oil barge transits. All noncompliant chemical barge transits passed deeper than 1.25nm into the Area.

The relatively small number of chemical barge transits that occurred during 2005 (14 total transits) is of import when investigating chemical barge compliance. Of the six noncompliant tugs towing chemical barges, four were Canadian flag vessels, and one was a Barbados flag vessel. Three of the transits involved the same (Canadian) tug. It is possible that the majority of these vessels passed through the ATBA because the vessel operators were unaware of its provisions or because they did not think that these provisions warranted serious consideration. This possibility is supported by the severity of the vessels' incursions into the ATBA (incursions that are distinct from those made by vessels that were clearly skirting the edge of the Area). If chemical barge noncompliance is driven primarily by a few vessels whose crews are unclear on the ATBA or its importance, chemical barge compliance rates might be significantly increased by a relatively limited education and outreach campaign focused on the operators of these vessels.

3.2 *Tugboat Compliance and Ports of Call*

Tugs towing oil and chemical barges through the Strait of Juan de Fuca call at numerous Canadian and United States ports. A review of data on compliant and noncompliant tugs' next ports of call could provide insight into whether a disproportionate amount of noncompliant tugs sail to specific ports.

The 2005 vessel traffic data was analyzed to determine the ports that tugs called at and the number of noncompliant and compliant tugs calling at each of these ports. For conformity with OCNMS' definition of compliance, twelve transits involving vessels that did not pass through the Sanctuary were excluded from this review of ports of call (see Section 1.3).

Compliant Tugs' Ports of Call	Number of Calls	Percentage of Calls
Alaska	1	0.19
Anacortes	91	17.30
Anchorage	2	0.38
Bellingham	22	4.18
California	21	3.99
Cherry Point	12	2.28
Columbia River	2	0.38
Commissioner Street, BC	1	0.19
Coos Bay	1	0.19
Everett	3	0.57
Ferndale	60	11.41
Long Beach	7	1.33
Los Angeles	4	0.76
Panama	1	0.19
Port Angeles	14	2.66
Portland	184	34.98
PetroCan (Vancouver, BC)	1	0.19
San Francisco	17	3.23
Seattle	37	7.03
Strait of Juan de Fuca	1	0.19
Tacoma	29	5.51
Vancouver, BC	11	2.09
Vancouver, WA	3	0.57
Unknown	1	0.19
TOTAL	526	100

Noncompliant Tugs' Ports of Call	Number of Calls	Percentage of Calls
Anacortes	1	1.72
California	5	8.62
New Westminister, BC	2	3.45
Portland	37	63.79
San Francisco	5	8.62
Seattle	1	1.72
Tacoma	3	5.17
Vancouver, BC	1	1.72
Vancouver, WA	3	5.17
TOTAL	58	100

Table 3 and Table 4: Compliant and noncompliant tugs' ports of call

Table 3 lists the ports that compliant transits ended at, the number of transits ending at each port, and the percentage of compliant transits ending at each port. Table 4 lists the ports that noncompliant transits ended at, the number of transits ending at each port, and the percentage of noncompliant transits ending at each port.

Portland clearly stands out in both the list of noncompliant tugs' ports of call, with 37 of 58 (almost 64%) of noncompliant transits ending at this port and in the list of complaint tugs' ports of call, with 184 of 526 (almost 35%) of compliant transits ending at the port. This finding is in accordance with the trends for liquid bulk transport outlined in the Washington Port Forecasts for 2004 (58), and draws attention to the Lower Columbia River as a port area frequented by oil barges.

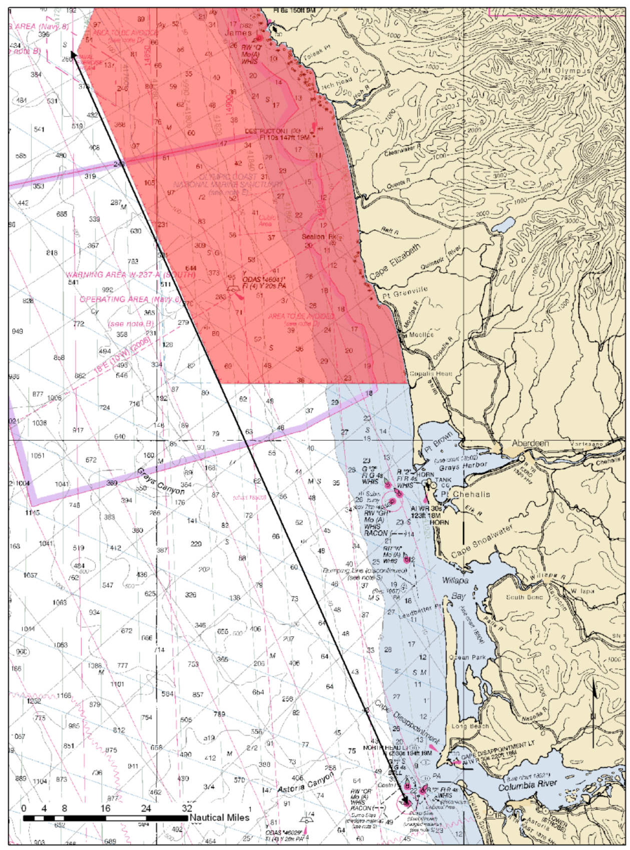

Figure 5: A hypothetical trackline between the westernmost point of the ATBA and the entrance to the Columbia River

In 2005, there were 331 laden barge transits through the Sanctuary. These 331 barges could have potentially made a noncompliant transit through the ATBA (based on OCNMS' definition of compliance that excludes vessels not passing through the Sanctuary, and based on the fact that the barges were carrying product). As outlined above, 58 of the 331 barges actually did make noncompliant transits through the ATBA. The 273 remaining barges were compliant with the Area's provisions. Two hundred out of the 273 laden compliant barges called at Columbia River ports while 41 out of the 58 noncompliant barges called at Columbia River ports. Focusing only on these tugs towing barges that had the potential to make a noncompliant transit, it does not appear that there is a large difference in the relative amount of compliant transits ending or beginning at Columbia River ports (approximately 73% of the compliant transits) and noncompliant transits ending or beginning at Columbia River ports (approximately 71% of the noncompliant transits)[15].

Data on tug tracklines in or around the whole ATBA would facilitate determination of whether tugs cut through the southern portion of the Area when bound to or from the Columbia River. While such an analysis is not possible with the OCNMS dataset due to Tofino VTS' radar coverage, it is questionable that there would be a large incentive for crews on board vessels sailing to Columbia River ports to transit the southern ATBA unless they also cut through the ATBA north of James Island. As depicted in Figure 5, tugs traveling along the boundary of the Area from abeam James Island are already set up on a straight-line track to Buoy *CR* at the entrance to the Columbia.

3.3 *Transits Through the ATBA as they Relate to the Two-Way Route in the Strait of Juan de Fuca*

In December of 2002, IMO established a "Recommended Two-Way Route" in the Strait of Juan de Fuca south of the pre-existing traffic separation scheme (TSS) (Figure 6).
IMO suggests that slower moving traffic, including tugs towing barges, use the Two-Way Route to reduce the occurrence of overtaking situations in the TSS (23). However, by keeping tug traffic closer to the Washington coast near the entrance to the Strait of Juan de Fuca, the Recommended Two-Way Route might provide tug operators with a greater incentive to transit the ATBA than tug operators using the lanes in the TSS. Based on this possibility that the Two-Way Route could set tugs up to transit the ATBA, OCNMS' 2005 vessel traffic data was reviewed to determine how many noncompliant tugs used the Route and to see if there was any association between tugs' use of the Route and passage through the ATBA.

[15] Even if laden transits through the Sanctuary ending at Columbia River ports (as opposed to laden transits through the Sanctuary either beginning or ending at Columbia River ports) are examined, there still does not appear to be a large difference between compliant and noncompliant transits. Forty out of 50 noncompliant transits (80%) outbound from the Strait of Juan de Fuca ended at Columbia River ports, while 183 out of 225 compliant transits (81.3%) outbound from the Strait of Juan de Fuca ended at Columbia River ports.

Analysis of tug tracklines in ArcView GIS permitted categorization of each tug transit with respect to the Two-Way Route. If a tug's trackline crossed the boundary of the Two-Way Route, that tug was classified as having used the Route. If a tug's trackline did not cross the boundary of the Two-Way Route, that tug was classified as not having used the Route. During 2005, 53 of the 58 noncompliant tug transits (50 tugs towing laden oil barges and three tugs towing laden chemical barges) involved tugs that used the Two-Way Route.

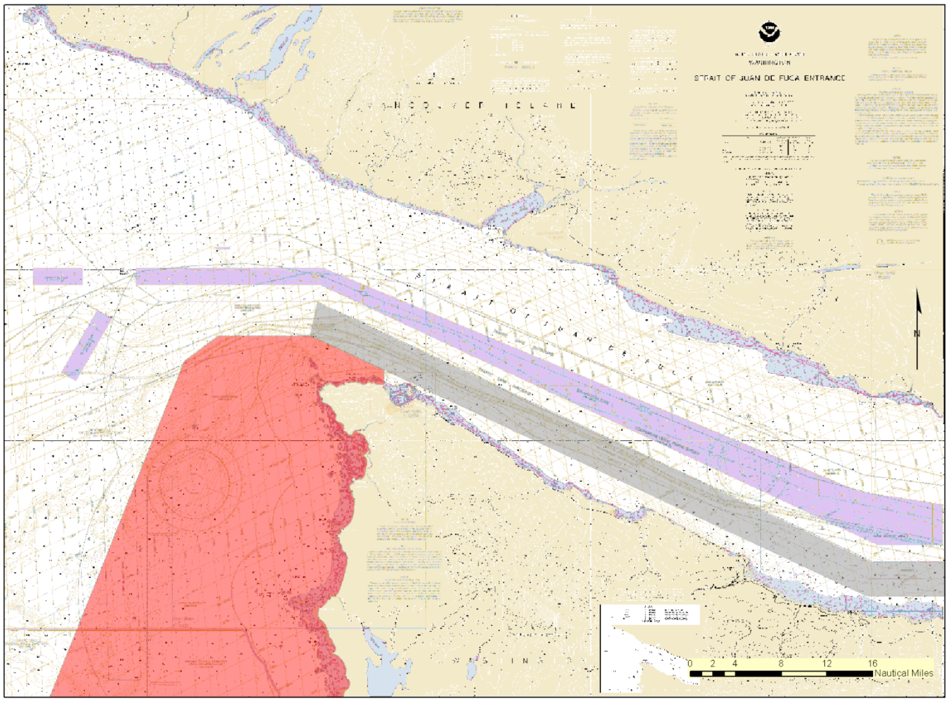

Figure 6: Two-Way Traffic Route (shaded grey; ATBA shaded red)

The West Coast Offshore Vessel Traffic Risk Management Project Workgroup recommends that "vessels 300 gross tons or larger transiting coastwise anywhere between Cook Inlet and San Diego should voluntarily stay a minimum of 25 nautical miles offshore" (17). Although this recommendation only officially applies where measures like the ATBA do not exist, it indicates the Workgroup's recognition that there is value in routing all large commercial vessels at least 25 nautical miles off the coast – even if these vessels are not transporting a cargo of oil or hazardous materials. As such, data on all tug traffic (empty and laden, compliant and noncompliant) was considered in an attempt to isolate a possible association between tugs' use of the Two-Way Route and tug passage through the ATBA during 2005. Tugs were classified based on whether or not they transited the ATBA and whether or not they used the Two-Way Route. Once again, the twelve tugs that did not pass through the Sanctuary at all were excluded from this analysis. Tug counts are outlined in Table 5.

	Use Two-Way Route	Not Use Two-Way Route	Total
In ATBA	100	10	110
Not in ATBA	398	76	474
Total	498	86	584

Table 5: Tug transits through the ATBA and the Two-Way Route

A chi square test of the Table 5 transit counts suggests an association between tugs' use of the Two-Way Route and passage through the ATBA, but does not provide conclusive evidence of such an association (p = .0888)[16]. Despite this inconclusive evidence of an association, it is clear that the percentage of tugs in the ATBA that used the Two-Way Route (approximately 91%) is greater than the percentage of tugs not in the ATBA that used the Two-Way Route (approximately 84%).

In considering these results, at least two uncertainties associated with the 2005 vessel traffic data as it applies to the Two-Way Route should be acknowledged. First, the entrance to the Route is near the outer edge of the Mt. Ozzard radar transceiver's range (Figure 7). Some tug tracklines end (Tofino radar coverage ends) west of the entrance to the Two-Way Route, so there could be tugs that used the Route but were not captured as such in this dataset. Failure to count these tugs would lead to an under representation of use of the Two-Way Route.

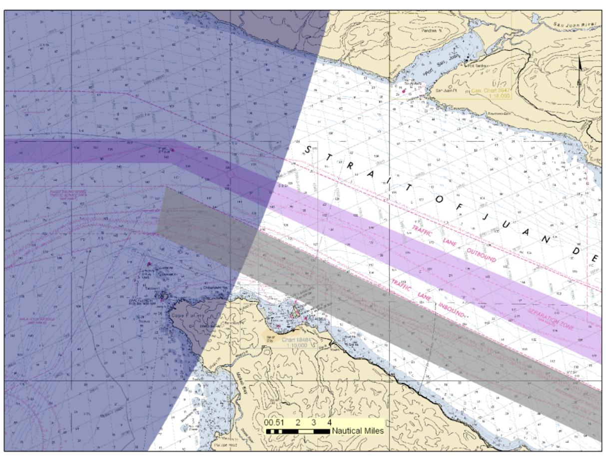

Figure 7: Mt. Ozzard transceiver coverage (shaded blue) and the western portion of the Two-Way Traffic Route (shaded grey)

[16] The chi square test, as applied to aggregated data like that in Table 5, could overlook lurking variables (some variable other than use of the Two-Way Route that impacts passage through the ATBA). Due to its inability to account for lurking variables, this chi square test only addressed the question, "Is there a relationship between tug passage through the ATBA and tug use of the Two-Way Route, *ignoring all other factors*" (59).

Second, some tugs could have passed through the Two-Way Route while headed for the inbound lane in the TSS. Tugs passing through the Two-Way Route for the TSS would be counted as having used the Route when they actually did not. Counting these tugs would lead to an over representation of the use of the Two-Way Route.

3.4 *Tugboat Compliance and Offshore Weather Conditions*

Offshore weather conditions could be one factor associated with a tugboat crew's decision to transit the ATBA while towing a laden barge. By cataloging weather conditions at the time of the 58 noncompliant transits through the ATBA and at the time of a random sample of transits that did not pass through the ATBA, it is possible to determine if more noncompliant transits were made when weather was poor than when it was good and to examine a potential association between weather and tug compliance.

OCNMS' 2005 vessel traffic data and NOAA NDBC data permitted quantification of offshore weather during tug transits. NDBC Station 46087 (Buoy *JA*) records wind speed and wind gusts once every half hour and wave height every hour on the hour. Station 46041 (Cape Elizabeth) records wind speed, wind gusts, and wave height every hour on the hour[17] (35). As outlined above, the Sanctuary's vessel traffic data includes the date and time of the first radar fix for each vessel transit. Wave height, wind speed, and wind gusts from the weather observation closest (temporally) to the time included in the OCNMS dataset were cataloged for all 58 noncompliant tug transits through the ATBA and for a random sample of 58 tug transits that passed through the Sanctuary but not the ATBA.

A weather classification scheme based on NOAA's Coastal Warning Display Program and on the rescue tug criteria outlined in the Final Report of the Emergency Towing System Task Force for the Washington State Office of Marine Safety was developed to facilitate analysis of this wind speed and wave height data (Table 6) (60, 61).

[17] Due to the possibility that Station 46087 might not provide a completely accurate representation of offshore weather conditions (see Section 2.6) and the fact that weather data was not available from Station 46087 (Buoy *JA*) for several tug transits, weather conditions at both Station 46087 and Station 46041 (Cape Elizabeth) were reviewed for this study.

Weather Class	Sustained Winds	Significant Wave Height
Light	Less than 21 knots (gusts up to 30 knots)	Less than 10 feet
Moderate	21 – 30 knots (gusts up to 40 knots)	10 – 12 feet
Severe	30 – 40 knots (gusts up to 50 knots)	12 – 18 feet
Extreme	Greater than 40 knots (gusts greater than 50 knots)	Greater than 20 feet

Table 6: Weather classification scheme

Raw data on weather conditions during noncompliant tug transits and the random sample of tug transits through the Sanctuary but not the ATBA were then categorized based on the weather classification scheme. The distributions of these tug transits, grouped by weather class, are outlined in Table 7 (Station 46087 data) and Table 8 (Station 46041 data).

	Light	Moderate	Severe	Extreme	Buoy Data Missing	Total
Noncompliant Transits	47	3	3	0	5	58
Transits through Sanctuary not ATBA	47	5	3	0	3	58
Total	94	8	6	0	8	116

Table 7: Number of tug transits during each weather class based on Station 46087 (Buoy *JA*) data

	Light	Moderate	Severe	Extreme	Buoy Data Missing	Total
Noncompliant Transits	46	5	7	0	0	58
Transits through Sanctuary not ATBA	44	7	7	0	0	58
Total	90	12	14	0	0	116

Table 8: Number of tug transits during each weather class based on Station 46041 (Cape Elizabeth) data

Regardless of the NDBC Station used as a source of weather data, the majority of noncompliant transits (81% based on Buoy *JA* data and 79% based on Cape Elizabeth data) took place when sustained winds were less than 21kts, wind gusts were less than 30kts, and significant wave heights were less than ten feet. A similar pattern holds for the sample of tug transits through the Sanctuary but not the ATBA – 81% of these transits occurred when weather was "Light" based on Buoy *JA* data and 76% of the transits occurred when weather was "Light" based on Cape Elizabeth data. Due to the amount of transits made when weather was “Light” and similarities between the relative number of noncompliant transits and transits through the Sanctuary but not the ATBA in each weather class, it does not appear as though there was an association between weather and noncompliant tug transits through the ATBA during 2005[18].

3.5 *Barge Direction of Travel as it Relates to Barge Status*

To facilitate determination of whether the provisions of the ATBA are applicable to a particular vessel, it has sometimes been assumed that the majority of tug transits into the Strait of Juan de Fuca are made in ballast. For example, Galasso cites communications with a representative from the American Waterways Operators and states “It is our understanding that inbound petroleum barges rarely carry product” as justification for focusing efforts at ATBA education and outreach on tugs not inbound for the Strait of Juan de Fuca (18). Data on all laden and empty petroleum barges’ next and last ports of call were reviewed to see if the assumption that inbound transits are generally made in ballast held for the 2005 calendar year.

Of the 596 total tug transits recorded in the 2005 OCNMS dataset, two transits involved vessels that were neither entering nor departing the Strait of Juan de Fuca (the vessels were engaged in activities along the outer coast of Vancouver Island), 12 transits involved vessels going in an unknown direction (data on last and next port of call was lost in decoding, or passage through the Strait of Juan de Fuca was not certain based on available next and last port of call data), and 14 transits involved tugs towing chemical barges. Direction of travel and barge status for the remaining 568 petroleum barge transits are outlined in Table 9.

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[18] This finding is supported by a logistic regression of the data, which indicates that weather is not a predictor of tug passage through the ATBA (Nagelkerke R-Square less than .001 for both Buoy *JA* and Cape Elizabeth data). A chi square test of the tug transits for the Cape Elizabeth data, ignoring all other factors, also shows virtually no evidence of an association between compliance and weather conditions ($p = 0.828$).

	Inbound	Outbound	Total
Empty	231	14	245
Laden	49	274	323
Total	280	288	568

Table 9: Status of inbound and outbound petroleum barges

It appears as though most inbound tugs towing petroleum barges (almost 83%) were transiting in ballast during 2005. Indeed, ignoring all other factors, there is convincing evidence of an association between a tug's direction of travel and barge status (chi square $p << 0.05$)[19].

As the assumption that most inbound transits are made in ballast has been specifically applied to tugs towing oil barges through the ATBA, data on the subset of 110 tugs towing barges that transited the ATBA during 2005 was reviewed. Nine of these 110 tugs were towing chemical barges, and one tug was going in an unknown direction. Direction of travel and barge status for the remaining 100 oil barges are outlined in Table 10:

	Inbound	Outbound	Total
Empty	44	4	48
Laden	5	47	52
Total	49	51	100

Table 10: Status of inbound and outbound petroleum barges passing through the ATBA

When considering only those petroleum barge transits that passed through the ATBA, almost 90% of inbound barges were traveling in ballast. Once again, ignoring all other factors, there is convincing evidence of an association between a tug's direction of travel through the ATBA and barge status (chi square $p << 0.05$)[20].

For 2005, omission of inbound tugs towing petroleum barges from education and outreach efforts would have resulted in the oversight of approximately 10% (five out of 52) of the total laden oil barge transits through the ATBA.

[19] As discussed above, the chi square test does not account for lurking variables (here, variables other than direction of travel) that might be related to barge status.
[20] The same caveats regarding lurking variables outlined above are applicable to this test.

3.6 *Incidents and Accidents*

This report does not attempt to formally assess the risk of an oil or hazardous materials barge-related spill along Washington's outer coast. However, quantification of historical incidents and accidents involving these vessels can provide a useful indication of the risks associated with oil and hazardous materials barge traffic. For example, the United States Coast Guard used historical oil spill data to help determine contemporary spill risks in their Regulatory Assessment of tugs as oil spill prevention tools. The Coast Guard's Risk Based Decision-Making Guidelines also validate a review of historical accidents, "Some of the best insight into possible accidents is based on information about the types, frequencies, and severities of past accidents in the same or similar operations" (56).

Relevant incidents and accidents involving tugs towing oil or hazardous materials barges along Washington's entire outer coast were cataloged for this study. Between 1994 (the year that OCNMS was designated) and the end of 2006, there were 14 of these events. Table 11 includes a list of the vessels involved in the casualties, the date the casualty occurred, and whether the casualty involved a broken towline or a loss of tug power or maneuverability.

Date	Tug / Barge	Broken Towline	Loss of Tug Power or Maneuverability
14 December 1995	*Sea Valiant* / *Oregon*	X	
26 September 1996	*Robert Bouchard* / *Bouchard Barge No. 235*		X
24 November 1998	*Robert L.* / *Columbia*	X	
17 February 1999	*Western Navigator* / Unknown Barge	X	
28 March 1999	*Ralph E. Bouchard* / *Bouchard Barge No. 230*	X	
12 February 2001	*Sterling V* / *N-67*		X
18 March 2001	*Sterling V* / *N-67*		X
29 April 2001	*Caribe Challenger* / *Barge SCT 340*		X
6 November 2001	*Sea Prince* / *Barge 360*		X
3 January 2002	*Pacific Avenger* / *Barge 103*		X
9 October 2002	*Altair* / *Rigel*		X
11 October 2003	*Ernest Campbell* / *Dottie*	X	
19 March 2005	*Howard Olsen* / *Millicoma*	X	
27 December 2006	*James T. Quigg* / *Nancy Jo*	X	

Table 11: Incidents and accidents involving tugs towing oil and chemical barges off Washington's outer coast (1994-2006)

In addition to these 14 casualties, there were another 15 events involving tugs and or barges for which data was too scarce to permit classification. Thirteen of these additional 15 events might not have involved tugs towing oil or chemical barges (barge type is unknown). The two remaining events involved oil tank barges, but took place at unknown locations[21]. Seven of the 15 additional events involved a loss or reduction of vessel power or maneuverability, six involved damage to the environment, and five involved other occurrences (grounding, loss of stability, sinking, or fire)[22].

See Appendix C for a more detailed summary of the circumstances surrounding all 29 accidents and incidents.

[21] These two casualties were listed in the Department of Ecology dataset, so it is likely that they occurred in or adjacent to Washington waters. However, they could have taken place in the Strait of Juan de Fuca, greater Puget Sound, or the Columbia River – not off the outer coast.
[22] Some casualties involved more than one of these occurrences.

CHAPTER 4: RECOMMENDATIONS FOR FUTURE RESEARCH

4.1 *Vessel Traffic Data*

Several limitations in the utility of Tofino VTS radar data as a tool to assess vessel compliance with the ATBA were outlined above. If future OCNMS compliance estimates based on Tofino VTS data are low enough to warrant concern and or increased scrutiny, Automatic Identification System (AIS) data on vessel traffic could permit a more precise review of ATBA compliance.

Vessels equipped with AIS transponders broadcast a variety of data in the maritime VHF band to other appropriately equipped vessels and shore stations. This data, including vessel call sign, course, speed over ground, and position, facilitates identification of and communication between vessels engaged in potentially conflicting operations. Positional data transmitted through AIS usually comes from a ship's global navigation satellite system (GNSS) (Global Positioning System (GPS) is a GNSS) (62). The positional accuracy of this GNSS data can be much greater than the positional accuracy of radar fixes like those from Tofino VTS' Mt. Ozzard transceiver[23]. AIS data on vessel position is also transmitted every two to ten seconds. As such, determination of vessel tracklines based on AIS data requires significantly less interpolation between positional fixes than is necessary for Tofino VTS data that is archived at six minute intervals[24].

In addition to increased accuracy, data from AIS shore stations along the Washington coast would permit monitoring of vessel traffic throughout the ATBA, not just its northern sector. Indeed, AIS data on the tracklines followed by vessels transiting Washington's outer coast could be used to support an assessment of oil spill risks to the entire coast, including the region south of the ATBA and the approaches to the Columbia River.

[23] The United States Coast Guard states that the positional error of a differential GPS position is typically around one to three meters (63).
[24] However, Galasso notes that a large volume of data storage space would be required for two to ten second positional fixes to be archived (25). Space restrictions might limit the amount of fixes that could be *stored*, despite the fact that these fixes are *collected* relatively frequently.

The Marine Exchange of Puget Sound (MAREX) is currently investigating the development and implementation of a variety of new AIS-based vessel tracking tools (64). AIS data on vessel traffic has not historically been archived in a manner that would permit its application in a review of ATBA compliance. However, MAREX recently began collecting AIS data on vessel transits through the ATBA that could support future compliance studies, and has started working with OCNMS to confirm the status of certain noncompliant transits (as recorded by the Mt. Ozzard radar transceiver) using AIS data. MAREX's new AIS positional information and cross-referenced reports on barge status[25] will be valuable resources for an ongoing assessment of ATBA compliance, especially if data on each vessel's position is collected and stored so as to permit analysis with GIS[26].

4.2 *Possible Association Between Vessels' Use of the Two-Way Route and Incursions into the ATBA*

The marginal evidence for an association between tugs' use of the Two-Way Route and passage through the ATBA (not significant evidence of an association at a .05 level, significant evidence of an association at a 0.1 level) revealed by the chi square test of the 2005 vessel traffic data highlights this issue as one that could bear further investigation. A more robust review of an association between use of the Two-Way Route and tug passage through the ATBA would be possible if several related factors were accounted for. First, some of the uncertainty outlined above (under representation of Route usage due to limited radar coverage and overrepresentation of Route usage due to vessel passage through the Route for the inbound lane in the TSS) could be reduced by reviewing vessel traffic data for tugs towing barges as they progress through the Strait of Juan de Fuca. Second, data from more than one year could help correct for anomalous traffic patterns that might have only presented during 2005. Third, use of more sophisticated statistical tools than a chi square test (such as logistic multiple regression) would permit several factors to be examined at one time and help overcome some of the issues of data aggregation that limit

[25] Representatives from MAREX contact the operator of tugs identified as towing barges through the ATBA to request information on whether those barges are empty or laden (64).
[26] For example, data on vessel position collected at a regular time interval throughout a vessel's transit, which could be converted into vessel tracklines in GIS (the same methodology currently used by OCNMS for Tofino VTS data) would be more useful than a static screenshot of the vessel's transit.

the chi square test in this application. Finally, it could be helpful to broaden the scope of any review of associations between use of the Two-Way Route and passage through the ATBA to include vessels other than tugs towing oil and chemical barges. Most tugs (approximately 85% in 2005) did use the Two-Way Route, and examining the incidence of vessel passage through the ATBA for a greater number of vessels that do not use the Route might provide a more solid basis for isolating an association between Route usage and transits through the ATBA.

However, even if an analysis that accounted for these additional factors revealed a definitive association between the Two-Way Route and incursions into the ATBA, this association should be considered in the context of the magnitude of the incursions and in the context of other spill risks near the entrance to the Strait of Juan de Fuca. While reviewing the Washington State Ferries Risk Assessment, Merrick et al. propose that marine transportation systems are inherently dynamic (65). Grabowski et al. suggest that this dynamism is important when considering risk mitigation measures as risks migrate in distributed, large-scale systems. The authors explain, "Risk migrates when the introduction of a risk mitigation measure to address one problem in the system introduces other, unintended consequences in another part of the system" (66). Although the Two-Way Route might be associated with transits through the ATBA, if these transits are relatively minor in severity, the spill risk created by the transits could be less than those created by overtaking or crossing situations in the TSS. Stated differently, it is possible that spill risks due to incursions into the ATBA associated with the Two-Way Route might be preferable to spill risks associated with traffic congestion in the TSS that would arise if vessels did not use the Two-Way Route.

4.3 *Incident and Accident Data*

The investigation of incidents and accidents carried out for this report highlights the somewhat unconsolidated, incomplete, and un-reviewed nature of some existing marine incident and accident data. These facets of incident and accident data can hinder analyses reliant on the data. For example, the West Coast Offshore Vessel Traffic Risk Management Project Workgroup states that "[USCG] data were challenging to interpret… with the limited amount of information recorded in the available databases, the Workgroup is hesitant to state unilaterally that any trends can be discerned" (17). Hindrances from limited incident and accident data are of concern as root cause analyses based on this data can be useful in developing spill prevention measures (56, 57). Expansion of incident and accident datasets to include more event information, coupled with the implementation of a quality control mechanism for this data, could help increase the rigor of future studies that use incident and accident data.

4.4 *Fish Processors in the ATBA*

Risks associated with fish processor activity in the ATBA could bear consideration. Fish processors, listed as "Fishing Vessels" in the VEAT compliance tables, have relatively low estimated ATBA compliance rates (75.2% in 2004, 77.2% in 2005, and 89.6% in 2006[27] (26-28)). OCNMS notes that these estimates might not be extremely meaningful with regard to ATBA compliance (26-28). While fish processors considered during the calculation of the VEAT compliance estimates are 1,600 gross tons and above, the ATBA applies to "ships 1,600 gross tons and above *solely in transit*" (23). Many of the fish processors in the ATBA might not be in transit[28]. Despite the fact that the ATBA compliance estimates for fish processors are questionable, the estimates do draw attention to possible risks associated with this type of vessel. Nuka Research and Cape International, Inc., highlight some of these risks, "fish processing vessels are typically large, carry a large amount of fuel, are relatively under-powered, and operate for long periods close to shorelines" (67). Investigation of fish processor activity in the ATBA might provide some indication of whether fish processors pose a disproportionately high risk of oil spills to Washington's northern outer coast.

[27] 2006 VEAT compliance estimates are based on vessel traffic data from only part of the 2006 calendar year (28).
[28] It also bears noting that the *total* number of fish processors passing through the ATBA is not exceptionally high (29 processors in the ATBA in 2004, 26 in 2005, and 7 in 2006) (26-28).

SUMMARY

Focused examination of vessel traffic and weather data from 2005 permitted the review of several facets of tugboat compliance with the ATBA. Estimates of tugboat compliance that distinguished between tugs towing empty and laden barges were calculated, and the magnitude of laden tugs' incursions into the ATBA was determined. Possible relationships between tug compliance and ports of call, between tugs' use of the Recommended Two-Way Route in the Strait of Juan de Fuca and passage through the ATBA, between tug compliance and offshore weather conditions, and between tug direction of travel (into or out of the Strait of Juan de Fuca) and barge status (empty or laden) were all investigated.

These analyses show that (for 2005):

- The estimated compliance rate for tugs towing oil barges is approximately 8% higher when empty oil barge transits through the ATBA are treated as compliant (estimated compliance rate of 90.9%) than when these transits are treated as noncompliant (estimated compliance rate of 82.5%)
- The estimated compliance rate for tugs towing chemical barges is approximately 21% higher when empty chemical barge transits through the ATBA are treated as compliant (estimated compliance rate of 57.1%) than when they are treated as noncompliant (estimated compliance rate of 35.7%)
- Most tugs towing laden oil barges through the ATBA did not pass deeper than one nautical mile into the Area
- Tugs towing laden chemical barges through the ATBA usually passed deeper into the Area than tugs towing laden oil barges, and low chemical barge compliance estimates were driven in part by a relatively small number of chemical barge transits
- A large portion of both compliant and noncompliant tug transits involved tugs calling at ports on the Lower Columbia River
- There is not conclusive evidence for an association between tug passage through the ATBA and tugs' use of the Two-Way Traffic Route in the Strait of Juan de Fuca
- There does not appear to be an association between tug compliance and offshore weather conditions, and most of the tug transits investigated occurred when weather conditions were relatively light

- There does appear to be an association between petroleum barge status and direction of travel; petroleum barges inbound for the Strait of Juan de Fuca were more likely to be transiting in ballast and petroleum barges outbound from the Strait were more likely to be transiting with product

In addition, a review of relevant incidents and accidents involving tugs towing oil or chemical barges off Washington's outer coast showed that, between 1994 and 2006, at least one incident or accident (on average) occurred per year.

If tug traffic patterns in and around the ATBA during 2005 serve as a reasonable representation of tug traffic patterns in and around the ATBA during other years, these findings should help guide decisions about prioritizing spill prevention efforts along Washington's northern outer coast.

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Appendix A: ATBA Compliance Estimates from *Vessel Entries and Transits for Washington Waters*, 2004-2006

Vessel Transits through the Olympic Coast National Marine Sanctuary and Area to be Avoided (ATBA)

see map on reverse side

During Calendar Year 2004

The International Maritime Organization (IMO), a specialized agency of the United Nations, has designated the Area to be Avoided (ATBA) off the coast of Washington to reduce the risk of marine casualties including oil spills, and the resulting environmental damage in the Olympic Coast National Marine Sanctuary (Sanctuary). Vessels advised to stay clear of this ATBA include all ships and barges carrying cargoes of oil or hazardous materials and all ships 1,600 gross tons and larger. The Olympic Coast National Marine Sanctuary, in cooperation with the U.S. and Canadian Coast Guards, monitors vessel compliance under this voluntary program. The Cooperative Vessel Traffic System (CVTS) collects data on all vessels entering and leaving the Strait of Juan de Fuca.

Vessel Type	Transits in and out of the Strait of Juan de Fuca recorded by the CVTS[1]	Transits passing through the Sanctuary[2]	Transits passing through the ATBA within the Sanctuary[3]	Estimated ATBA Compliance Rate[4]
	1	2	3	4
Bulk Carriers	2960	2023	36	98.2%
Container Ships	2784	1855	20	98.9%
Oil Tankers	822	518	1	99.8%
Tugs with Oil Barges	642	573	142	75.2%
General Cargo ships	537	423	3	99.3%
Vehicle Carriers	480	370	3	99.2%
Chemical Tankers	406	289	2	99.3%
Roll-on Roll-off Vessels(RORO)	352	208	2	99.0%
Cruise Ships	313	200	8	96.0%
Articulated Tank Barges	266	263	4	98.5%
Fishing vessels	200	117	29	75.2%
Log Carriers	44	0	N/A	N/A
Refrigerated Ships	41	28	1	96.4%
Ore-Bulk-Oil Vessels (OBO)	27	15	0	100.0%
Tugs with Chemical Barges	21	16	9	43.8%
Cable Layers	18	13	0	100.0%
Non-oil Tankers	17	10	0	100.0%
Heavy Load Carriers	12	12	0	100.0%
Liquefied Petroleum Gas Carriers (LPG) and Liquified Natural Gas (LNG) Carriers	9	5	0	100.0%
TOTALS	**9951**	**6938**	**260**	96.3%

(Footnotes)

[1] The vessel transits in this column were provided by the Cooperative Vessel Traffic System (CVTS) and include commercial vessels greater than 1600 gross tons, or tugs with oil or chemical barges.

[2] This column includes a subset of the CVTS vessel transits through the Sanctuary.

[3] This column includes a subset of the Sanctuary vessel transits that also go through the ATBA. These are vessels potentially not complying with the provisions of the ATBA. This is not known with certainty. For example, in some cases fishing processors do not transit the ATBA, but are engaged in operations within the ATBA and are therefore not subject to ATBA provisions. In other cases tank barges may be transiting while in ballast and not carrying petroleum products or chemicals.

[4] This column shows the percentage of vessels transiting through the Sanctuary that stayed out of the ATBA {Column 4 = 1 – (Column3/Column2)}. This is used as an estimate of compliance with ATBA provisions.

VEAT ATBA Compliance Estimates, 2004 (26)

Vessel Transits through the Olympic Coast National Marine Sanctuary and Area to be Avoided (ATBA)

see map on reverse side

During Calendar Year 2005

The International Maritime Organization (IMO), a specialized agency of the United Nations, has designated the Area to be Avoided (ATBA) off the coast of Washington to reduce the risk of marine casualties including oil spills, and the resulting environmental damage in the Olympic Coast National Marine Sanctuary (Sanctuary). Vessels advised to stay clear of this ATBA include all ships and barges carrying cargoes of oil or hazardous materials and all ships 1,600 gross tons and larger. The Olympic Coast National Marine Sanctuary, in cooperation with the U.S. and Canadian Coast Guards, monitors vessel compliance under this voluntary program. The Cooperative Vessel Traffic System (CVTS) collects data on all vessels entering and leaving the Strait of Juan de Fuca.

Vessel Type	Transits in and out of the Strait of Juan de Fuca recorded by the CVTS[1]	Transits passing through the Sanctuary[2]	Transits passing through the ATBA within the Sanctuary[3]	Estimated ATBA Compliance Rate[4]
	1	**2**	**3**	**4**
Container Ship	2,989	1,959	10	99.5%
Bulk Carriers	2,925	1,980	24	98.8%
Oil Tankers	898	636	5	99.2%
General Cargo ships	595	477	1	99.8%
Tugs with Oil Barges	582	570	100	82.5%
Vehicle Carriers	467	367	6	98.4%
Chemical Tankers	375	261	1	99.6%
Roll-on Roll-off Vessels(RORO)	362	222	3	98.6%
Cruise Ships	326	209	4	98.1%
Articulated Tank Barges	283	283	0	100.0%
Fishing vessels	194	114	26	77.2%
Heavy Load Carriers	33	28	0	100.0%
Refrigerated Ships	27	15	1	93.3%
Liquefied Petroleum Gas Carriers (LPG) and Liquified Natural Gas (LNG) Carriers	18	6	0	100.0%
Non-oil Tankers	16	10	0	100.0%
Cable Layers	14	11	0	100.0%
Ore-Bulk-Oil Vessels (OBO)	14	8	0	100.0%
Tugs with Chemical Barges	14	14	9	35.7%
TOTALS	**10,132**	**7,170**	**191**	97.3%

(Footnotes)

[1] The vessel transits in this column were provided by the Cooperative Vessel Traffic System (CVTS) and include commercial vessels greater than 1600 gross tons, or tugs with oil or chemical barges.

[2] This column includes a subset of the CVTS vessel transits through the Sanctuary.

[3] This column includes a subset of the Sanctuary vessel transits that also go through the ATBA. These are vessels potentially not complying with the provisions of the ATBA. This is not known with certainty. For example, in some cases fishing processors do not transit the ATBA, but are engaged in operations within the ATBA and are therefore not subject to ATBA provisions. In other cases tank barges may be transiting while in ballast and not carrying petroleum products or chemicals.

[4] This column shows the percentage of vessels transiting through the Sanctuary that stayed out of the ATBA {Column 4 = 1 – (Column3/Column2)}. This is used as an estimate of compliance with ATBA provisions.

VEAT ATBA Compliance Estimates, 2005 (27)

Vessel Transits through the Olympic Coast National Marine Sanctuary and Area to be Avoided (ATBA)

see map on reverse side

During Calendar Year 2006 (excluding June 1 - August 11)[1]

The International Maritime Organization (IMO), a specialized agency of the United Nations, has designated the Area to be Avoided (ATBA) off the coast of Washington to reduce the risk of marine casualties including oil spills, and the resulting environmental damage in the Olympic Coast National Marine Sanctuary (Sanctuary). Vessels advised to stay clear of this ATBA include all ships and barges carrying cargoes of oil or hazardous materials and all ships 1,600 gross tons and larger. The Olympic Coast National Marine Sanctuary (Sanctuary), in cooperation with the U.S. and Canadian Coast Guards, monitors vessel compliance under this voluntary program. The Cooperative Vessel Traffic System (CVTS) collects data on all vessels entering and leaving the Strait of Juan de Fuca.

Vessel Type	Transits in and out of the Strait of Juan de Fuca recorded by the CVTS[2]	Transits passing through the Sanctuary[3]	Transits passing through the ATBA within the Sanctuary[4]	Estimated ATBA Compliance Rate[5]
	1	2	3	4
Bulk Carriers	2,400	1,710	22	98.7%
Container Ship	2,243	1,549	15	99.0%
Oil Tankers	795	598	7	98.8%
General Cargo ships	454	374	5	98.7%
Vehicle Carriers	400	327	5	98.5%
Tugs with Oil Barges	366	358	78	78.2%
Roll-on Roll-off Vessels(RORO)	283	169	2	98.8%
Chemical Tankers	274	192	3	98.4%
Articulated Tank Barges	235	222	1	99.5%
Cruise Ships	209	133	1	99.2%
Fishing vessels	108	67	7	89.6%
Non-oil Tankers	33	21	1	95.2%
Heavy Load Carriers	19	17	0	100.0%
Refrigerated Ships	14	8	0	100.0%
Tugs with Chemical Barges	14	14	6	57.1%
Cable Layers	10	10	5	50.0%
Liquefied Petroleum Gas Carriers(LPG) and Liquified Natural Gas (LNG) Carriers	8	5	0	100.0%
Ore-Bulk-Oil Vessels (OBO)	5	3	0	100.0%
TOTALS	**N/A**	**N/A**	**N/A**	97.3%

(Footnotes)

[1] Due to changes in processing routines there is a data gap from June 1 through August 11 at 1000 AM; therefore, for 2006 we are only reporting the estimated compliance rates and not the total number of transits.

[2] The vessel transits in this column were provided by the Cooperative Vessel Traffic System (CVTS) and include commercial vessels greater than 1600 gross tons, or tugs with oil or chemical barges.

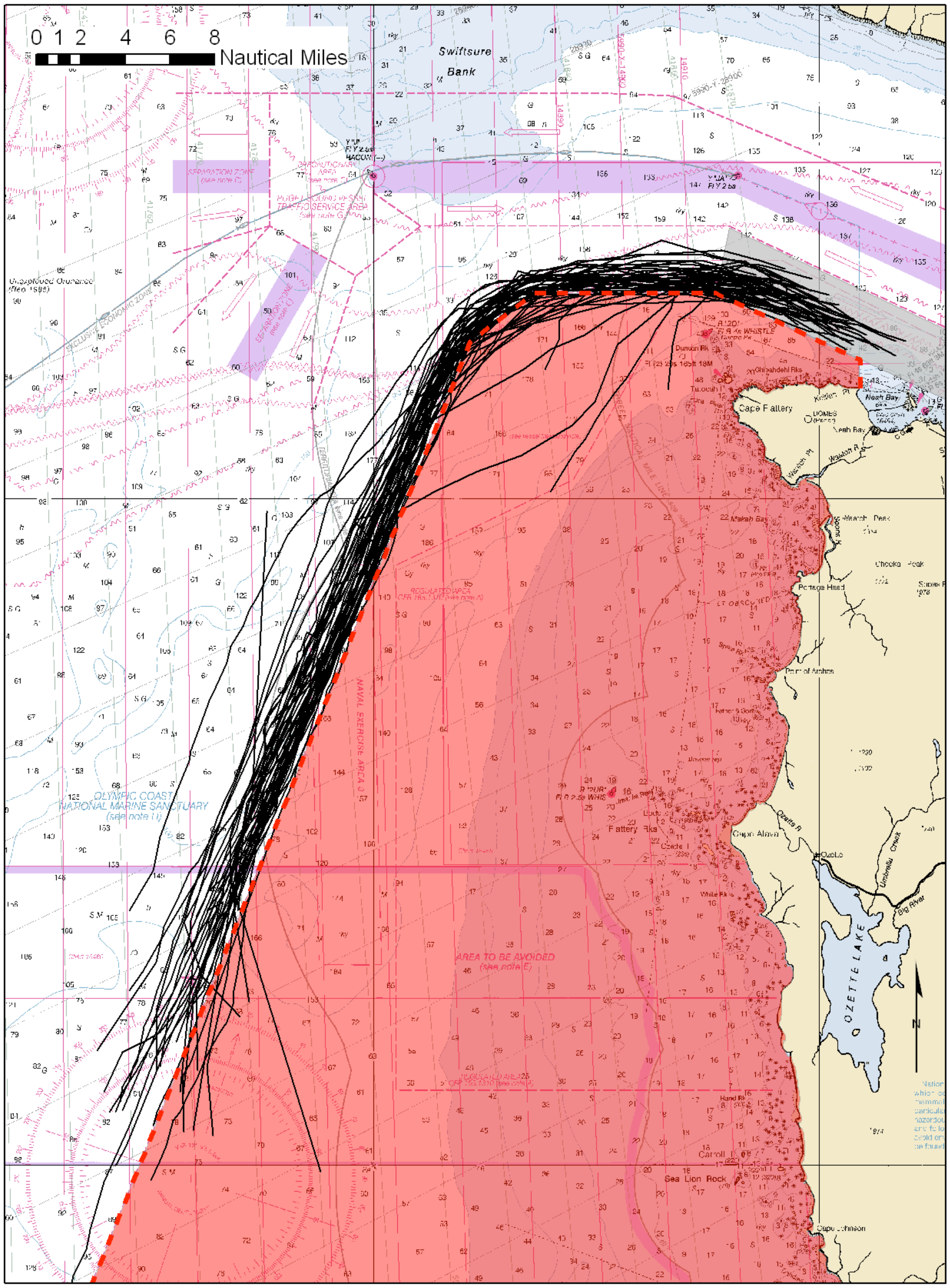
[3] This column includes a subset of the CVTS vessel transits through the Sanctuary.

[4] This column includes a subset of the Sanctuary vessel transits that also go through the ATBA. These are vessels potentially not complying with the provisions of the ATBA. This is not known with certainty. For example, in some cases fishing processors do not transit the ATBA, but are engaged in operations within the ATBA and are therefore not subject to ATBA provisions. In other cases tank barges may be transiting while in ballast and not carrying petroleum products or chemicals.

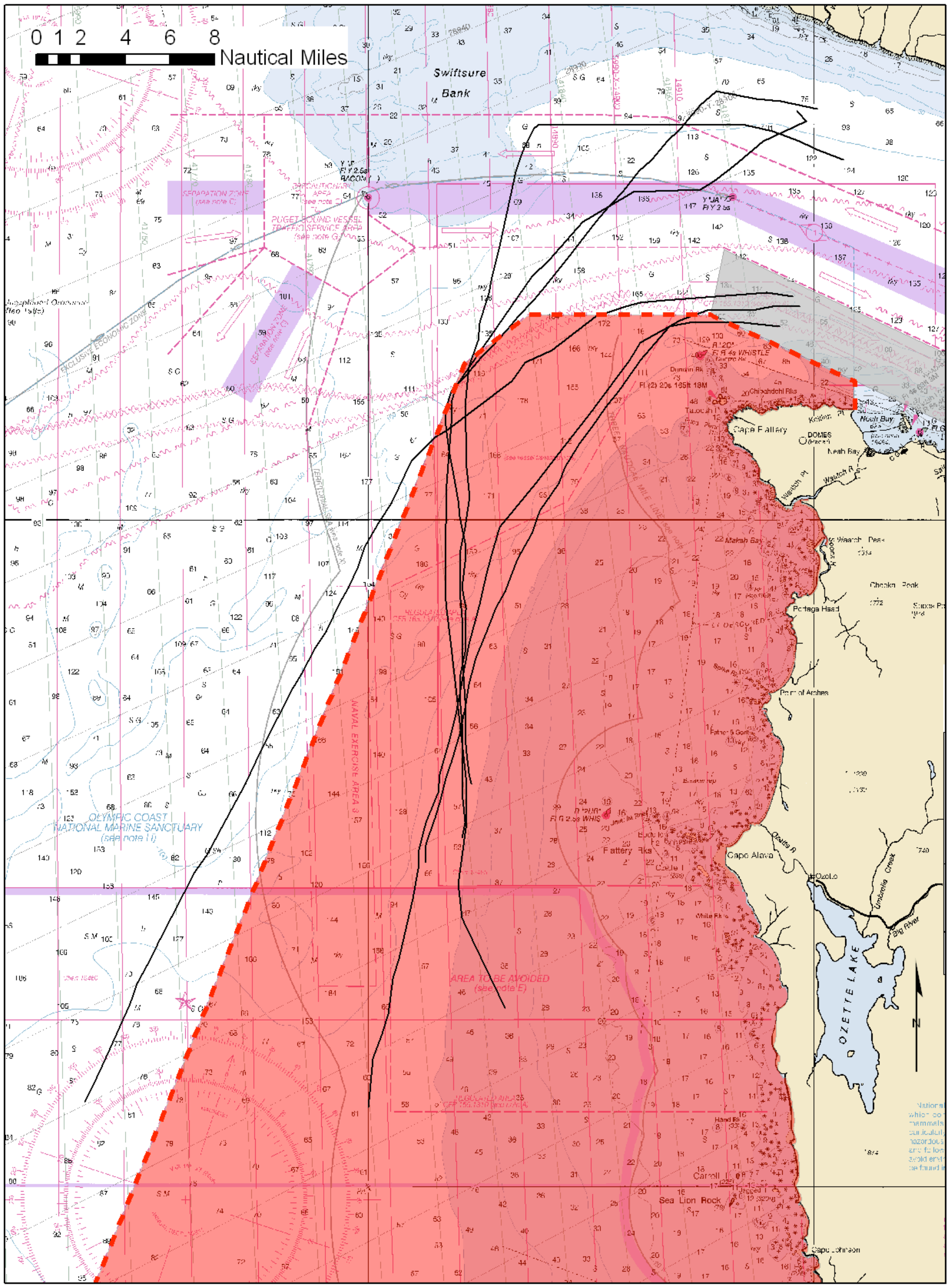
[5] This column shows the percentage of vessels transiting through the Sanctuary that stayed out of the ATBA {Column 4 = 1 – (Column3/Column2)}. This is used as an estimate of compliance with ATBA provisions.

VEAT ATBA Compliance Estimates, 2006 (28)

Appendix B: Noncompliant Tug Transits, 2005



Tracklines of noncompliant tugs towing oil barges during 2005; each black line represents one tug transit. ATBA is shaded red, Two-Way Route is shaded grey.



Tracklines of noncompliant tugs towing chemical barges during 2005; each black line represents one tug transit. ATBA is shaded red, Two-Way Route is shaded grey.

Date and Time of Transit	Tow	Last Port of Call	Next Port of Call	Direction	Flag State	Season	Severity of Intrusion (nm)	Use Two-Way Traffic Lane	Weather Conditions: Buoy *JA*	Weather Conditions: Cape Elizabeth
2005-01-02-1714	Oil Barge	Ferndale	Portland	Outbound	US	Winter	<0.25	Yes	Light	Light
2005-01-10-1055	Oil Barge	Ferndale	Portland	Outbound	US	Winter	2.25-2.50	No	Light	Light
2005-01-15-1731	Oil Barge	Port Angeles	Portland	Outbound	US	Winter	<0.25	Yes	Moderate	Moderate
2005-01-16-2026	Oil Barge	Tacoma	California	Outbound	US	Winter	1.75-2.00	Yes	Light	Light
2005-01-19-0452	Oil Barge	Port Angeles	Portland	Outbound	US	Winter	2.00-2.25	Yes	Severe	Moderate
2005-01-24-1517	Oil Barge	Ferndale	Portland	Outbound	US	Winter	0.50-0.75	Yes	Light	Light
2005-01-28-0049	Oil Barge	Vancouver, BC	Portland	Outbound	US	Winter	<0.25	Yes	Light	Light
2005-02-02-0824	Oil Barge	Anacortes	San Francisco	Outbound	US	Winter	1.00-1.25	Yes	Light	Light
2005-02-11-0025	Oil Barge	Vancouver, BC	Portland	Outbound	US	Winter	0.50-0.75	Yes	Light	Light
2005-02-11-1137	Oil Barge	Tacoma	San Francisco	Outbound	US	Winter	0.25-0.5	Yes	Light	Light
2005-03-12-1115	Oil Barge	Vancouver, WA	Anacortes	Inbound	US	Winter	4.00-4.25	Yes	Light	Moderate
2005-03-17-0047	Oil Barge	Vancouver, BC	Portland	Outbound	US	Winter	0.25-0.50	Yes	Light	Moderate
2005-03-22-1820	Oil Barge	California	Vancouver, BC	Inbound	US	Spring	<0.25	Yes	Light	Light
2005-04-03-0358	Oil Barge	Port Angeles	Portland	Outbound	US	Spring	<0.25	Yes	Light	Severe
2005-04-06-1839	Oil Barge	Port Angeles	Portland	Outbound	US	Spring	0.25-0.50	Yes	Moderate	Severe
2005-04-08-1349	Oil Barge	Bellingham	Portland	Outbound	US	Spring	<0.25	Yes	Light	Light
2005-04-22-1646	Oil Barge	Ferndale	Portland	Outbound	US	Spring	<0.25	Yes	Light	Light
2005-04-26-0848	Oil Barge	Los Angeles	Tacoma	Inbound	US	Spring	<0.25	No	Light	Light
2005-05-04-2357	Oil Barge	Port Angeles	Portland	Outbound	US	Spring	<0.25	Yes	Light	Light
2005-05-12-1058	Oil Barge	Anacortes	Portland	Outbound	US	Spring	0.75-1.00	Yes	Light	Light
2005-05-18-1015	Oil Barge	Anacortes	Portland	Outbound	US	Spring	<0.25	Yes	Light	Severe
2005-05-18-1059	Oil Barge	Anacortes	Portland	Outbound	US	Spring	0.50-0.75	Yes	Light	Severe
2005-05-25-2358	Oil Barge	Anacortes	Portland	Outbound	US	Spring	<0.25	Yes	Light	Light
2005-06-02-1748	Oil Barge	Anacortes	Portland	Outbound	US	Spring	0.50-0.75	Yes	Light	Light
2005-06-08-0504	Oil Barge	Anacortes	Portland	Outbound	US	Spring	0.75-1.00	Yes	Light	Light
2005-06-16-1017	Oil Barge	Ferndale	Portland	Outbound	US	Spring	<0.25	Yes	Light	Light
2005-06-28-1036	Oil Barge	Anacortes	Portland	Outbound	US	Summer	<0.25	Yes	Light	Light
2005-08-02-0020	Oil Barge	Anacortes	Portland	Outbound	US	Summer	<0.25	Yes	Light	Light
2005-08-07-0754	Oil Barge	Seattle	San Francisco	Outbound	US	Summer	1.50-1.75	Yes	Light	Light
2005-08-07-1927	Oil Barge	Anacortes	Portland	Outbound	US	Summer	1.50-1.75	Yes	Light	Light
2005-08-15-1323	Oil Barge	Long Beach	Tacoma	Inbound	US	Summer	5.25-5.50	Yes	Light	Light
2005-08-22-0144	Oil Barge	Tacoma	California	Outbound	US	Summer	0.50-0.75	Yes	Light	Light
2005-08-22-1529	Oil Barge	Vancouver, BC	Portland	Outbound	US	Summer	<0.25	Yes	Light	Light
2005-08-28-1530	Oil Barge	Anacortes	Portland	Outbound	US	Summer	1.00-1.25	Yes	Light	Light
2005-08-30-1619	Oil Barge	Ferndale	Portland	Outbound	US	Summer	0.50-0.75	Yes	Light	Light
2005-09-09-2020	Oil Barge	Tacoma	California	Outbound	US	Summer	<0.25	Yes	Severe	Severe
2005-09-20-1948	Oil Barge	Ferndale	San Francisco	Outbound	US	Summer	<0.25	Yes	Light	Light
2005-09-24-1447	Oil Barge	Seattle	Portland	Outbound	US	Fall	0.25-0.50	Yes	Light	Light
2005-09-27-0623	Oil Barge	Tacoma	California	Outbound	US	Fall	<0.25	Yes	Light	Light
2005-10-28-0953	Oil Barge	Port Angeles	San Francisco	Outbound	US	Fall	2.75-3.00	Yes	Light	Moderate
2005-10-29-1103	Oil Barge	Ferndale	Portland	Outbound	US	Fall	<0.25	Yes	Moderate	Severe
2005-11-11-1827	Oil Barge	Anacortes	Portland	Outbound	US	Fall	0.25-0.50	Yes	Severe	Severe
2005-11-19-1644	Oil Barge	Bellingham	Portland	Outbound	US	Fall	<0.25	Yes	Weather Data Not Available	Light

Date and Time of Transit	Tow	Last Port of Call	Next Port of Call	Direction	Flag State	Season	Severity of Intrusion (nm)	Use Two-Way Traffic Lane	Weather Conditions: Buoy *JA*	Weather Conditions: Cape Elizabeth
2005-11-20-0126	Oil Barge	Anacortes	Portland	Outbound	US	Fall	<0.25	Yes	Weather Data Not Available	Light
2005-11-20-2142	Oil Barge	Cherry Point	Portland	Outbound	US	Fall	<0.25	Yes	Weather Data Not Available	Light
2005-11-22-0759	Oil Barge	Port Angeles	Portland	Outbound	US	Fall	<0.25	Yes	Light	Light
2005-11-23-0738	Oil Barge	Richmond	Tacoma	Inbound	US	Fall	<0.25	Yes	Light	Light
2005-11-30-1518	Oil Barge	Ferndale	Portland	Outbound	US	Fall	<0.25	Yes	Light	Light
2005-12-03-0423	Oil Barge	Ferndale	Portland	Outbound	US	Fall	7.00-7.25	Yes	Light	Light
2005-12-06-0521	Oil Barge	Ferndale	Portland	Outbound	US	Fall	1.50-1.75	Yes	Weather Data Not Available	Light
2005-12-09-0029	Oil Barge	Anacortes	Portland	Outbound	US	Fall	0.25-0.50	Yes	Weather Data Not Available	Light
2005-12-16-2022	Oil Barge	Tacoma	California	Outbound	US	Fall	0.75-1.00	Yes	Light	Light
2005-02-03-2307	Chemical Barge	Vancouver, BC	Vancouver, WA	Outbound	Canada	Winter	11.25-11.50	No	Light	Light
2005-03-14-2129	Chemical Barge	Honolulu	Seattle	Inbound	US	Winter	1.25-1.50	Yes	Light	Light
2005-03-18-1638	Chemical Barge	Commissioner Street, BC	Vancouver, WA	Outbound	Canada	Winter	6.50-6.75	No	Light	Light
2005-06-29-1808	Chemical Barge	Vancouver, BC	Vancouver, WA	Outbound	Canada	Summer	7.00-7.25	No	Light	Light
2005-06-30-1353	Chemical Barge	California	New Westminister	Inbound	Barbados	Summer	6.00-6.25	Yes	Light	Light
2005-09-04-1431	Chemical Barge	California	New Westminister	Inbound	Canada	Summer	7.75-8.00	Yes	Light	Light

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Appendix C: Incidents and Accidents off the Washington Coast, 1994-2006

Date	Tug	Barge	Description[1]	Barge Type and Satus[2]	Data Source
20-May-94	*Joseph T*	Unknown	Approximately 25 nautical miles northwest of Cape Elizabeth (47.51667, -124.66667), an event occurred which involved damage to the environment.	Barge type and status unknown.	USCG Dataset
15-Sep-95	*Just Fisch*	Unknown	Approximately 26 nautical miles west of Willapa Bay (46.7, -124.51667), an event occurred which involved a total loss of vessel maneuverability.	Barge type and status unknown.	USCG Dataset
14-Dec-95	*Sea Valiant*	*Oregon*	Twenty seven nautical miles west of Point Grenville, *Sea Valiant* lost its tow (a brake on the tow machine failed, stripping all the tow wire off the machine). After approximately five hours, *Sea Valiant* was able to rig a temporary tow arrangement.	Barge *Oregon* is not listed in the ABS Record. The barge was laden with 12,500 tons of urea.	References 18 and 41
29-Jan-96	*Cindy Lou*	Unknown	Approximately 24 nautical miles northwest of Cape Disappointment (46.45, -124.36667) an event occurred which involved damage to the environment and sinking.	Barge type and status unknown.	USCG Dataset
31-Mar-96	*F.V. Lillian S*	Unknown	Approximately 37 nautical miles west northwest of Cape Alava (48.24333, -125.345), an event occurred which involved damage to the environment.	Barge type and status unknown.	USCG Dataset
17-May-96	*Arctic Hooper*	Unknown	Approximately 11 nautical miles west of Cape Disappointment (46.27833, -124.23833), an event occurred which involved a grounding.	Barge type and status unknown.	USCG Dataset
26-Sep-96	*Robert Bouchard*	*Bouchard Barge No. 235*	*Robert Bouchard*, inbound from San Francisco for Ferndale with *Bouchard Barge No. 235* in tow, reported issues with its port main engine. *Robert Bouchard* was operating at reduced speed on account of these issues.	Barge *B. No. 235* is a Double Hull Oil Tank Barge. Barge status unknown.	Department of Ecology Dataset
3-Jul-97	*Marie M*	Unknown	Approximately 30 nautical miles west of Grays Harbor (46.91833, -124.66833), an event occurred which involved damage to the environment and sinking.	Barge type and status unknown.	USCG Dataset
2-Feb-98	*Mary B*	Unknown	Approximately 130 nautical miles west of Grays Harbor (47, -126.33333), an event occurred which included a total loss of vessel maneuverability, fire, and grounding.	Barge type and status unknown.	USCG Dataset
24-Nov-98	*Robert L*	*Columbia*	*Robert L.* and *Columbia*, unable to cross the Columbia River bar on account of heavy weather, were in a hold offshore. Approximately 19 nautical miles west of the entrance to the Columbia River (46.21, -124.39833), the towline between the tug and barge parted. The barge drifted north northeast then north. *Robert L.* successfully used an Orville Hook to retrieve the tow on the morning of 25 November. *Columbia* was towed to Port Angeles.	*Columbia* is a Double Hull Fuel Oil Tank Barge. Barge status unknown.	Department of Ecology Dataset; USCG Dataset; Reference 18
17-Feb-99	*Western Navigator*	Unknown	At an unknown location off the Washington coast, the towline between *Western Navigator* and its barge parted in heavy seas. Two hours later, the tow was re-established with an Orville Hook.	Barge is listed as a "Petroleum Barge." Specific barge type and status are unknown.	Reference 18
28-Mar-99	*Ralph E. Bouchard*	*Bouchard No. 230*	Approximately 17.5 miles west of La Push, the towline between *Ralph E. Bouchard* and *Bouchard No. 230* parted during a storm. *Sea Valiant*, dispatched to assist late on 28 March, arrived on scene early 29 March. *Ralph E. Bouchard* remade the tow on the morning of 29 March 10 nautical miles west of Cape Flattery and was escorted to Port Angeles by *Sea Valiant*.	Barge *B No. 230* is a Double Hull Oil Tank Barge. The barge was empty except for diesel for barge generators.	Department of Ecology Dataset; References 5 and 44
8-Jul-99	Unknown	*DW 282*	A vessel at an unknown location (inbound for Seattle) suffered from a malfunctioning port Z-drive. The vessel continued making way under power from its starboard Z-drive.	*DW* 282, now *SCT-282*, is an Oil Tank Barge. Barge status unknown.	Department of Ecology Dataset
18-Aug-99	*Pacific Falcon*	Unknown	Approximately 4 nautical miles north northwest of Toleak Point (47.86667, -124.5833), an event occurred which involved damage to the environment.	Barge type and status unknown.	USCG Dataset
20-Dec-00	*C.F. Campbell*	Unknown	Approximately 36 nautical miles west of Willapa Bay (46.66667, -124.66667), an event occurred which involved a partial reduction in vessel maneuverability.	Barge type and status unknown.	USCG Dataset
12-Feb-01	*Sterling V*	*N-67*	Approximately 10 miles north of the entrance to Grays Harbor, *Sterling V* (bound for Port Angeles) suffered from a broken main engine shaft. *Sterling V*, making a maximum speed of 4.5 knots on one engine, arranged to meet with an escort tug near J Buoy for escort into Port Angeles.	Barge *N-67*, now *Yukon*, is an Oil Tank Barge. The barge was laden with 5,200 barrels of product.	Department of Ecology Dataset

[1]When duplicate events were included in a particular dataset or data on one event was available from several sources, all information on the event was combined to create one description. Some of these accounts include direct citations from the sources outlined in the column labeled "Data Source."

[2]When possible, barge type was confirmed using American Bureau of Shipping's (ABS) database of vessels in class with the Bureau (ABS Record). For certain barges, the name included in an accident report did not exactly match a barge listed in ABS Record. If the name included in ABS Record was similar to that outlined in the accident report, it was assumed that the same barge was being discussed (for example, barge *Bouchard No. 230* was assumed to be the same as barge *B. No. 230).* Names of barges are listed in this column as they appear in ABS Record and in the "Barge" column as they appear in the event report.

Date	Tug	Barge	Description[1]	Barge Type and Satus[2]	Data Source
18-Mar-01	*Sterling V*	*N-67*	Approximately 40 nautical miles northwest of Cape Flattery (48.49167, -125.36667), *Sterling V* broke a quill shaft from the starboard main engine. Tug *Bo Brusco* met with *N-67* on the morning of 18 March; tug *Hunter D* met with *N-67* early on 19 March.	Barge *N-67*, now *Yukon*, is an Oil Tank Barge. The barge was laden with 52,000 gallons of residual fuel oil.	Department of Ecology Dataset; USCG Dataset
29-Apr-01	*Caribe Challenger*	*Barge SCT 340*	Approximately 54 nautical miles southwest of Alava (47.63333, -125.16667), *Caribe Challenger* suffered from engine failure (port main). *Barbara Foss* was dispatched to escort *Caribe Challenger*; shortly after the vessels entered the Strait of Juan de Fuca, *Howard Olsen* replaced *Barbara Foss*, escorting *Caribe Challenger* and *SCT 340* to Anacortes.	Sea Coast Transportation's Barge *340* is a Deck Cargo and Oil Tank Barge. The barge was laden with 2,000,000 gallons of gasoline.	Department of Ecology Dataset; USCG Dataset; Reference 44
6-Nov-01	*Sea Prince*	*Barge 360*	*Sea Prince* suffered from engine failure (port main) while towing *Barge 360* from Anacortes to Portland. The tug's operators decided against attempting to cross the Columbia River bar on one engine and *Sea Prince* returned to Port Angeles for repairs.	Crowley *Barge 360* is an Oil Tank Barge. The barge was laden with 49,000 barrels of diesel oil and 30,000 barrels of gasoline.	Department of Ecology Dataset
3-Jan-02	*Pacific Avenger*	*Barge 103*	Approximately 15 miles west of Cape Flattery, *Pacific Avenger* lost power steering while towing *Barge 103* from Puget Sound to Portland. *Barbara Foss* escorted *Pacific Avenger* and *Barge 103* back to Port Angeles.	*Barge 103*, now *Pac Rim Express*, is a Deck Barge. The barge was laden with 2,100,000 gallons of diesel oil.	Department of Ecology Dataset; Reference 44
4-Sep-02	*Sea Flyer*	Unknown	Approximately 3 nautical miles from the entrance to the Columbia River (46.22011, -124.13727), an event occurred which involved a loss in stability (shift of cargo, passengers, or gear).	Barge type and status unknown.	USCG Dataset
9-Oct-02	*Altair*	*Rigel*	Near the entrance to the Strait of Juan de Fuca (approximately 2 miles from Neah Bay), *Altair* suffered from engine failure (failure of one of two screws). *Barbara Foss* took *Altair* and *Rigel* under tow. At Port Angeles, tug *Nakoa* took *Rigel* in tow for Portland.	*Rigel* is a Double Hull Oil and Chemical Tank Barge. The barge was laden with 80,000 barrels of diesel oil.	Reference 44
28-Jan-03	*Halle Foss*	Unknown	Approximately 12 nautical miles west of Willapa Bay (46.66667, -124.2725), an event occurred which involved damage to the environment (oil discharge).	Barge type and status unknown.	USCG Dataset
25-Aug-03	*Henry Sause*	Unknown	Approximately 13 nautical miles west of Willapa Bay (46.66667, -124.27639), an event occurred which involved total loss of electrical power.	Barge type and status unknown.	USCG Dataset
11-Oct-03	*Ernest Campbell*	*Dottie*	Approximately 20 nautical miles west southwest of Cape Flattery (48.324823, -125.03083), the towline between *Ernest Campbell* and *Dottie* was severed by attack submarine *USS Topeka*. *Barbara Foss* was dispatched to assist. Around three hours after the towline was severed, *Ernest Campbell* successfully re-established the tow using an Orville Hook. The barge had drifted approximately 8 miles north northeast. *Barbara Foss* escorted *Ernest Campbell* and *Dottie* to Port Angeles.	*Dottie* is a Double Hull Oil Tank Barge. The barge was empty.	USCG Dataset; Reference 42
6-May-04	*Seaspan Sovereign*	Unknown	Approximately 3 nautical miles from the entrance to the Columbia River (46.22011, -124.13727), an event occurred which involved a partial reduction in vessel maneuverability.	Barge type and status unknown.	USCG Dataset
19-Mar-05	*Howard Olsen*	*Millicoma*	Near the Columbia River bar, the towline between *Howard Olsen* and *Millicoma* parted in severe weather. The barge grounded in a cove north of the mouth of the Columbia River and was successfully re-floated on 23 March.	Barge *Millicoma* is not listed in ABS Record. Accident reports indicate that the barge is a Double Hull Tank Barge. The barge was empty except for 5,000 gallons of diesel oil to power barge generators.	References 45-50
20-Aug-05	*El Lobo Grande*	*Capella*	At an unknown location, *El Lobo Grande* suffered from the failure of a starboard reduction gear clutch while towing *Capella*.	*Capella* is a Double Hull Oil Tank Barge. Barge status unknown.	Department of Ecology Dataset
27-Dec-06	*James T. Quigg*	*Nancy Jo*	Approximately 25 miles west of Ocean Shores, the tow wire between *Nancy Jo* and *James T. Quigg* parted. *Millennium Star* was dispatched to assist. Two hours after the towline parted, *James T. Quigg* was successful in using an Orville Hook to reconnect to *Nancy Jo*. On 28 December, *James T. Quigg* and *Nancy Jo* safely crossed the Columbia River bar under escort by *Millennium Star*.	*Nancy Jo* is an Oil Tank Barge. The barge was laden with 35,000 barrels of heavy fuel oil.	Reference 43

[1]When duplicate events were included in a particular dataset or data on one event was available from several sources, all information on the event was combined to create one description. Some of these accounts include direct citations from the sources outlined in the column labeled "Data Source."

[2]When possible, barge type was confirmed using American Bureau of Shipping's (ABS) database of vessels in class with the Bureau (ABS Record). For certain barges, the name included in an accident report did not exactly match a barge listed in ABS Record. If the name included in ABS Record was similar to that outlined in the accident report, it was assumed that the same barge was being discussed (for example, barge *Bouchard No. 230* was assumed to be the same as barge *B. No. 230).* Names of barges are listed in this column as they appear in ABS Record and in the "Barge" column as they appear in the event report.